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# Vertical Mixing Rates on Georges Bank During June-July and October, 1988

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## ABSTRACT

Oakey, N.S., and R.G. Pettipas. 1992. Vertical mixing rates on Georges Bank during June-July and October, 1988. Can. Data Rep. Hydrogr. Ocean Sci. No. 110: iv + 226 pp.

Estimates of vertical mixing rates on Georges Bank have been obtained from the measurements of microstructure and turbulence during two cruises during the summer and fall of 1988. These measurements were obtained using the profiler EPSONDE at six sites instrumented with current meters. At each mooring site the ship was anchored and the instrument deployed repeatedly from the surface to the bottom over a tidal period. The hourly averaged estimates of $\chi_\theta$, the dissipation of temperature fluctuations; Cox Number, a measure of mixing rate; $K_t$ and $K_\rho$, vertical diffusivities for temperature and density; and $\varepsilon$, viscous dissipation rate are presented for each anchor station. Estimates of the rate of viscous energy loss or dissipation integrated over the water column have been determined and compared to the current field and are presented for each anchor station.



## RESUME

Oakey, N.S., and R.G. Pettipas. 1992. Vertical mixing rates on Georges Bank during June-July and October, 1988. Can. Data Rep. Hydrogr. Ocean Sci. No. 110: iv + 226 pp.

Des estimations des taux de mélange vertical sur le banc de Georges ont été obtenus à partir de mesures de microstructure et de turbulence au cours de deux sorties à l'été et à l'automne 1988. Ces mesures ont été obtenues avec le profileur EPSONDE en six endroits équippés de courantomètres. À chaque point d'amarrage, le navire a été ancré et l'instrument déployé de façon répétée depuis la surface jusqu'au fond pendant la période d'une marée. Les estimations moyennes horaires de $\chi_\theta$, coefficient de dissipation des fluctuations de température; le nombre de Cox, mesure du taux de mélange; $K_t$ et $K_\rho$, les diffusivités vertical de température et de densité; et $\varepsilon$, le taux de dissipation viscqueuse sont présentés pour chaque point d'ancrage. Les estimations du taux de perte ou de dissipation d'énergie viscqueuse, intégrée sur l'ensemble de la collone d'eau, ont été déterminées et comparées au champ de courant et sont présentées pour chaque point d'ancrage.

## INTRODUCTION

During the period of June 23 to October 17, 1988 an extensive program of physical and biological measurements was conducted on Georges Bank (Loder, 1988; Oakey, 1988a,b). The experiment was focused around six moorings shown in Figure 1. The array consisted of a westward line of four moorings at a spacing of about 10 kilometers extending from number 1 in deeper water off the Bank edge where there is strong stratification to number 4 in the well mixed water on the bank. To the east there were two more moorings, number 5 in stratified water off the Bank and number 6 on the bank. The current structure from these moorings has been discussed elsewhere (Loder, Pettipas and Belliveau, 1990; Loder and Pettipas, 1991). During this field program turbulent vertical mixing rates were estimated by using the profiler EPSONDE during the Dawson cruise 88023 from June 23 to July 13 and during the Dawson cruise 88036 from September 29 to October 17. It is the intention of this data report to describe and present these data.

## DATA COVERAGE

At each of the mooring sites, microstructure studies were done with the ship at anchor about 1 km from the current meter mooring. Figure 2 summarizes these anchor stations as a time line for the period of the June - July cruise (88023) and the October cruise (88036). It should be noted that the two eastern moorings were recovered at mid-July at the end of cruise 88023 so there are only four sites for 88036. Each anchor station is identified by four numbers and characters: the mooring site (1..6), the sequential anchor station at that site (A..C) and 23 for 88023 of 36 for 88036. For example, 4B23 was the second anchor station at mooring site 4 on cruise 88023. A gap of about 5 days exists between 3A23 on June 29 and 4A23 on July 3, a result of the loss of EPSONDE 1 and the time required to make EPSONDE 2 fully operational. The instrument loss occurred during 2A23 so no data are available for this site. There were 13 anchor stations in all, each covering about a tidal period. Two stations show a hatched region in the time line: 1A23 was interrupted by another operational requirement and 2A36 was interrupted by bad weather.

During each anchor station, EPSONDE was profiled repeatedly as described below and individual sampling times are available in the sections to follow. The labelling for each of the thirteen sections of the data summary follows the same identification code as in Figure 2.

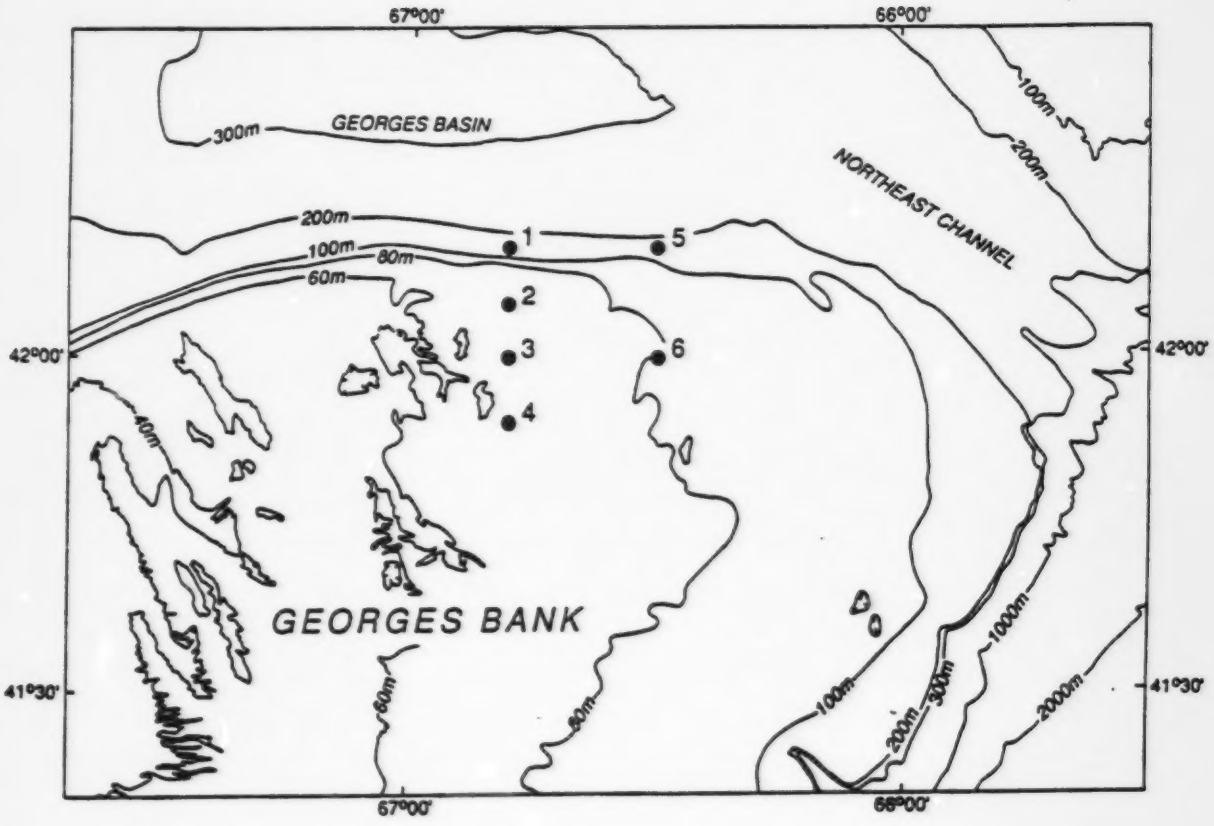



Figure 1. The mooring array for the Georges Bank Frontal Study is shown. There are a total of 6 moorings indicated by numbered dots superimposed on the bottom bathymetry.

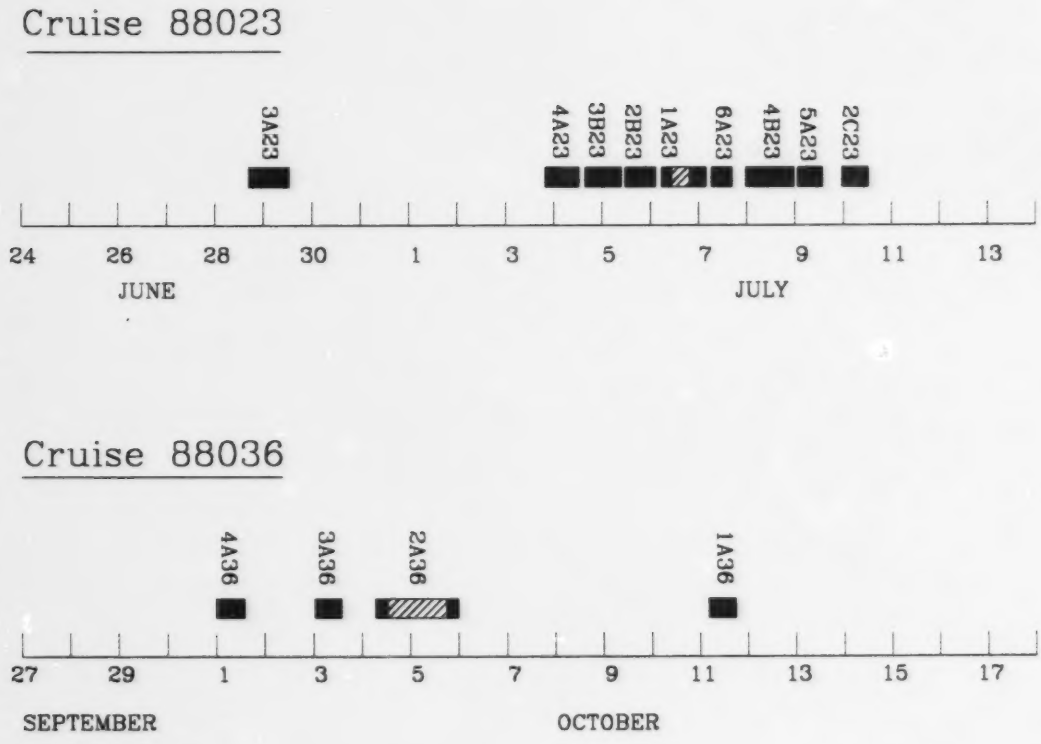



**Figure 2. The EPSONDE anchor station time periods for the summer (88023) and fall (88036) cruises are shown on a time-line.**

## THE PROFILING INSTRUMENT, EPSONDE

The data set consists of turbulence data obtained with the microstructure profiler EPSONDE (Oakey, 1988c) and mean velocity data obtained from a variety of current meters (discussed below). EPSONDE is described in detail in Oakey, 1988 but some information is included here for completeness. EPSONDE is a tethered free-fall vertical profiler, negatively ballasted to fall at a speed of about 0.5 to 1.0 $ms^{-1}$. It is deployed on a loose tether line which is used for recovery purposes; data are telemetered to the ship through conductors in this line. It measures temperature and velocity microstructure using sensors mounted on a leading sting. For the Georges Bank experiment a guard ring was installed on this sting to protect the sensors and allow us to profile to within 0.05 m from the bottom.

Energy dissipation, $\varepsilon$, is obtained from EPSONDE by measuring the turbulent velocity fluctuation profiles (or velocity microstructure) using velocity shear probes. From power spectra derived from these profiles one obtains the total variance in the velocity shear field, $\overline{(\partial u/\partial z)^2}$ $s^{-2}$. The dissipation is given by (Osborn, 1980)

$$\varepsilon = 7.5\upsilon \overline{(\partial u/\partial z)^2} \qquad W\ kg^{-1}.$$

where $\upsilon$ is the kinematic viscosity ($\upsilon = 1.3 \times 10^{-7} m^2 s^{-1}$). At the same time the temperature microstructure measurements allow us to estimate the temperature gradient variance, $\overline{(\partial T'/\partial z)^2}$ $^oC^2m^{-2}$. The dissipation of temperature gradients is estimated as

$$\chi_\theta = 6\ D\ \overline{(\partial T'/\partial z)^2} \quad {}^oC^2s^{-1}$$

where D is the molecular diffusivity ($D = 1.4 \times 10^{-7} m^2 s^{-1}$). The vertical diffusivity for density is given as

$$K_\rho = 0.25\ \varepsilon/N^2 \quad m^2s^{-1}$$

where 0.25 is a mixing efficiency (Osborn, 1980) and N is the buoyancy frequency. Alternatively, the vertical diffusivity for heat is given by

$$K_T = 3\ D\ \frac{\overline{(\partial T'/\partial z)^2}}{(\partial \bar{T}/\partial z)^2} \qquad m^2s^{-1}$$

where $(\partial \bar{T}/\partial z)$ is the mean temperature gradient (Osborn and Cox, 1972). The quantity $\frac{\overline{(\partial T'/\partial z)^2}}{(\partial \bar{T}/\partial z)^2}$ which is the ratio of the variance in the temperature field divided by the square of the mean temperature gradient is often referred to as the Cox number.

During the Georges Bank study, the C.S.S. Dawson was anchored within 1 km of a fixed mooring site which was instrumented to measure current speed and direction. At approximately hourly intervals for a typical period of a tidal cycle, EPSONDE was deployed to obtain a BURST of (usually) eight profiles from the surface to the bottom within a 30 to 40 minute period. A CTD profile was taken and the cycle repeated. At anchor with typical surface tidal currents of 0.5 to 1.0 $ms^{-1}$ the ship swung around its anchor with the scope of its anchor chain (typically a radius of 200 m). EPSONDE was deployed from the stern of the vessel and streamed astern during its descent.

## MICROSTRUCTURE DATA ANALYSIS

Data from each profile were edited to find the best estimate of the last sample that occurred before the instrument hit the bottom. The pressure sensor was sampled at 32 HZ and the microstructure sensors at 256 HZ which at 0.8 $ms^{-1}$ corresponds respectively to 2.5 cm and 0.8 cm vertically. The precision of the estimate was much worse than this, however. The instrument drop velocity was scanned to determine when the instrument stopped falling and the corresponding depth taken as the bottom. Noise on the pressure signal, however, made it difficult to determine this accurately to better than about 0.25 meters. The determination was further complicated by the fact that the pressure sensor is at the top of the 2.4 meter long pressure case and the instrument hit the bottom with the probe guard and then (presumably) fell over in the strong current. The estimate of the bottom of the profile is considered accurate to $\pm 0.25$ m. In some cases the instrument never reached the bottom because insufficient tether line was deployed for the current speed.

Having determined the bottom for each profile, the data were analyzed in SEGMENTS of two seconds (512 points) from near the surface to the bottom, blocked so that the end of the last segment corresponded to the last good data point at the end of the profile. Each segment for a profile was analyzed to obtain spectra of the turbulent velocity and temperature microstructure time-series using well established spectral analysis techniques. For each segment average quantities such as mean depth, temperature and temperature gradient were determined. For signals analyzed spectrally, frequency response corrections for sensor and electronic transfer functions were applied and the variance determined after the contribution of noise and spikes were removed. As defined above, the viscous dissipation, $\varepsilon$, was determined from the turbulence variance dissipation and $\chi_\theta$, the dissipation of temperature fluctuations, was

obtained from the temperature microstructure variance. The result (for a drop speed of approx 0.8 $ms^{-1}$) was a profile of average values of $\varepsilon$, $\chi_\theta$, $\partial T/\partial z$, T and other derived quantities over a SEGMENT of about 1.6 meters.

All of the profiles from an hourly BURST were averaged together and vertically averaged in bins of 5 meters to give a single BURST averaged profile for each station. This time-series of BURST average profiles forms the basis set of data for merging with other data such as CTD data or current meter data.

## CURRENT METER DATA

Current speed and directions for this data report were obtained from the data base for the Georges Bank Study of 1988. These are discussed in detail by Loder, Pettipas and Belliveau (1990) and Loder and Pettipas (1991). From the larger data set, sections of the current meter (RCM) measurements corresponding to the periods of the anchor stations were extracted. In general, these data represented half hourly measurements of rate and direction at several depths in the water column. At each anchor station the rate and direction were also measured using a shipboard Ametek Straza acoustic doppler current profiler (ADCP). It yielded approximately 10 minute average rates and directions for depth bins of approximately 3.1 meters from about 8 meters of the surface to a depth typically 10 meters from the bottom. These data were averaged to half hour time intervals to correspond to the current meter times. The resulting merged RCM and ADCP data file thus consisted of north (V) and east (U) current rates at half hour intervals assigned to an appropriate depth interval. One quantity of particular interest to compare to dissipation measurements is the depth averaged current, $U_{AVG}$ and $V_{AVG}$. These depth averaged north and south rates were obtained by integrating each component, dividing by the depth, and forming the DEPTH AVERAGED RATE from the vector sum of these two.

For example, the mooring at Site 3 in 67 m mean depth contained Aanderaa current meters at 12, 34, 57 and 64 meters depth which recorded the rate over 30 minutes and the direction at the end of each record interval. An acoustic doppler current meter (Ametek Straza) mounted on the ship anchored at a site less than 1 km away from a mooring array was used to determine velocities for depths from 8.8 to 55.3 m (in 3.1 m bins). As a special example of an anchor station, burst averaged profiles of dissipation data for station 3B23 at Site 3 are shown in Figure 3a. Each burst average of dissipation was plotted at

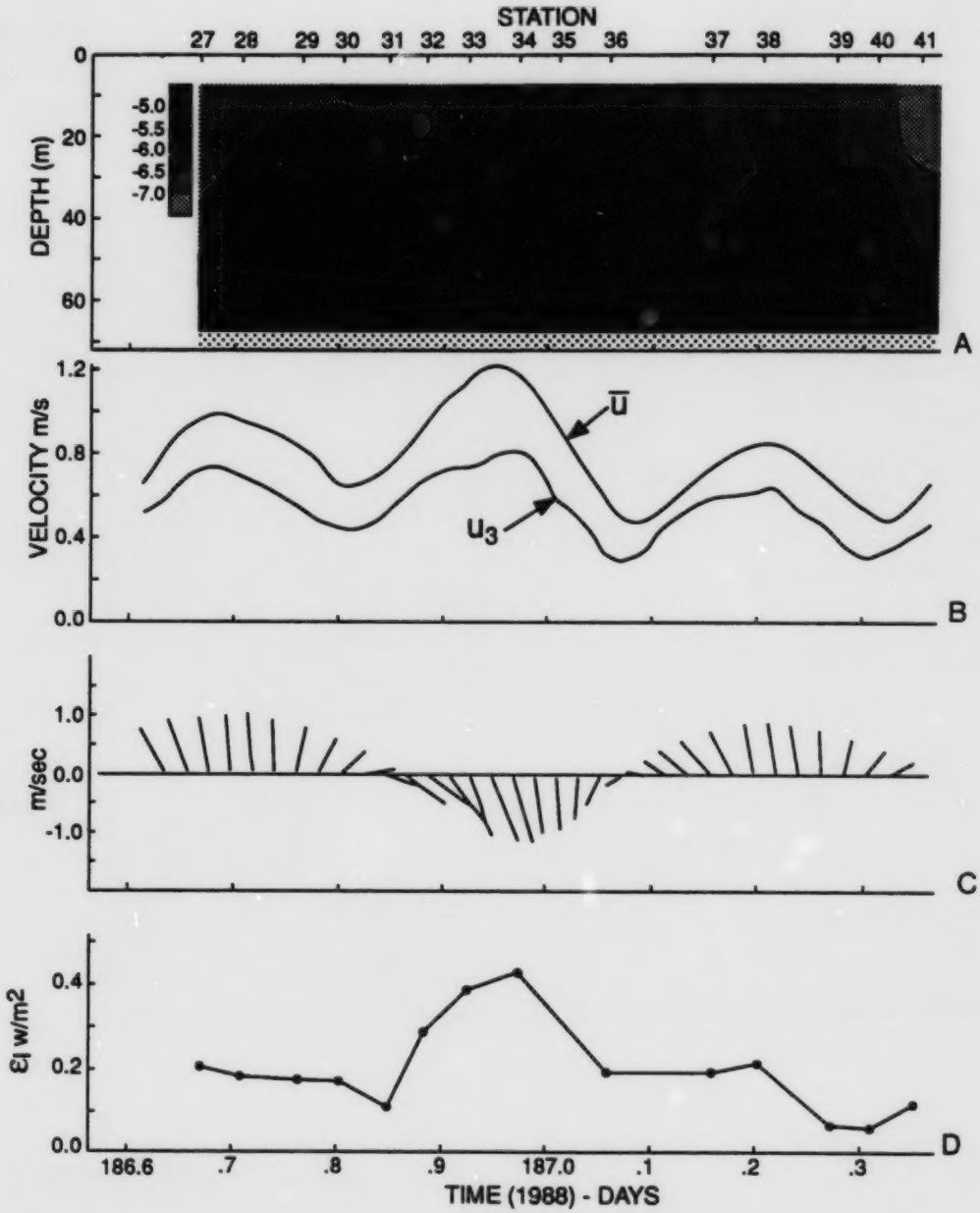



Figure 3. For site 3B23, dissipation, $\varepsilon$, from hourly averages of measurement of turbulence are shown in (a) contoured at intervals of 0.5 in Log($\varepsilon$). In (d), the dissipation is shown integrated over the water column. Corresponding magnitude of the depth averaged current ($\bar{U}$) and the current 3 meters from the bottom are shown in (b) while the mid-depth current vector is shown in (c)

the time it was measured and the data have been contoured at intervals of 0.5 in Log($\varepsilon$). It can be clearly seen that the most intense periods of turbulence occurred at the times when the the depth averaged rate is greatest, Figure 3b. In this realization, the current is strongest and is flowing on-bank (Figure 3c) at about day 187.0 at which time the dissipation is highest and the integrated dissipation shown in Figure 3d is a maximum (about 0.4 $w/m^2$). In the data presentation to follow, averaged currents and integrated dissipations will be shown but contoured plots are not shown.

## THE ERRORS ASSOCIATED WITH MICROSTRUCTURE QUANTITIES

Of particular interest to the understanding of mixing rates on Georges Bank is to be able to average the quantities appropriately or determine the integral over the water column correctly and assign error bars. The accuracy of measuring dissipation and temperature variance with EPSONDE has been addressed previously (Oakey, 1982). For the data summaries presented, all good profiles in a station were averaged. Each profile, as discussed above, consists of data sorted into 5 meter vertical bins. Thus, in averaging stations, one measure of the error is the variability which occurs for each 5 meter bin. This quantity has been calculated but is not presented here explicitly for every bin and station because it is not clear that it is a meaningful quantity. One would expect that the intermittence of turbulence will make numbers associated with individual depth bins very variable in time. For this report, a typical variance for this quantity is considered sufficient.

For each 5 meter bin with a measured microstructure quantity $M_i$ the average was calculated to be $\overline{M} = J^{-1} \sum_1^J M_i$ ,

the Variance determined by $VAR = (J-1)^{-1} \sum_1^J (M_i - \overline{M})^2$ ,

and the Standard Error of the Mean is $SDMean = J^{-1/2}$ VAR.

In the Site Summaries, station profiles for CHI-THETA, VERT-DIFFUSIVITY, DISSIPATION, and COX NUMBER are the averages as defined above. Typically the Standard Error of the Mean for 5 meter bins are of the order of 1/3 of the average.

In the present data report the vertical integral of dissipation has been included. Some detail of the efforts to calculate this appropriately are in order. For every profile included in a station, the integral is calculated simply by finding

$$\text{IntMSTR} = \sum_{1}^{J} \text{MSTR(i)} \times \text{DELDPTH(i)}$$

where IntMSTR may be any microstructure quantity, for example dissipation, $\varepsilon$; MSTRI(i) is the measured microstructure in a SEGMENT with depth interval, DELDPTH(i), at depth, DPTH(i). The sum is carried out from the surface (DPTH = 0) to the bottom (DPTH = DBOTTOM). (The anchor station bottom depth is taken to be the average for the station from profiles and soundings.) There are several problems with this in practice because of information lost at the surface and at the bottom.

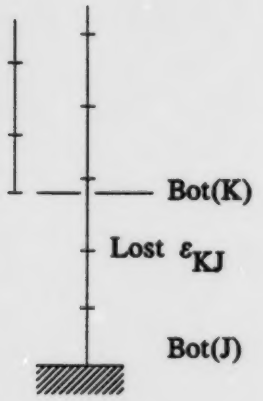
Microstructure measurements are made from a few meters below the surface to a depth which may be as close as 0.05 m. from the bottom. Ship and surface effects contaminate the data at the beginning of a profile and a suitable correction must be made for this in integrating over the water column. In the Georges Bank analysis depths closer than 8 meters from the surface are considered to be contaminated and are rejected. To compensate, a surface correction is added to the dissipation using the station (or BURST) average dissipation in the top two bins of the mean profile below 8 meters averaged and scaled according to the depth interval that is missed. In the current experiment there was little surface forcing compared to the tidal forcing so this correction generally is only a few percent of the integral.

At the bottom of an EPSONDE profile there are several circumstances that must be considered in correcting the data. As discussed above, the maximum depth of each profile was determined with an accuracy of $\pm 0.25$ m. There are several cases of importance.

FIRST CASE: for any profile in the BURST that goes to the bottom all of the variance is measured and no bottom correction is needed.

SECOND CASE: if there is a profile which goes to within 0.4 meters (or 0.25 DELDPTH(segment)) from the bottom it is assumed that the deepest measured segment can be extended to the bottom and the correction is applied based on making DELDPTH large enough to meet the bottom. This is considered a minor correction and is not recorded as a bottom dissipation correction in the final table.

THIRD CASE: If at least one profile of a BURST goes to the bottom other profiles in the BURST are corrected by assuming that the lost variance from the deepest point in the profile is the in the same ratio to the total variance in the profile as it is in the profiles measured to the bottom. If more than one profile in the BURST goes to the bottom then the correction is based on all the profiles that go to the bottom.




The variance of profile J which reaches the bottom is $\varepsilon_J$ with bottom, Bot(J) = DBOTTOM and the measured variance of profile K is $\varepsilon_K$ and goes to depth Bot(K). It therefore loses the variance in the depth interval Bot(K)-Bot(J). The variance over this interval is calculated for profile J, denoted Lost $\varepsilon_{KJ}$, by summing the dissipation in each segment or part of segment as done above in IntEPS. The proportion of variance measured in profile K (in reference to profile J) is then assumed to be $P_{KJ}=(\varepsilon_J - \varepsilon_{KJ})/\varepsilon_J$. The average $<P_K> = J^{-1}\sum_J P_{KJ}$ . This is the average portion of the profile measured in respect to full profiles. The estimated total dissipation for profile K is then $\varepsilon_K/<P_K>$ or the correction to be added to profile K is calculated as

$$\varepsilon_{corrK} = \varepsilon_K(1 - <P_K>)/<P_K>.$$

FOURTH CASE: if no profiles go to the bottom then the deepest profile in the BURST is treated as the bottom and the three cases above are dealt with. A further correction must be applied to those BURST averages not reaching the bottom. This must be estimated by comparison with other BURSTS using a fraction of the lost dissipation similar to the THIRD CASE approach.

The dissipations for each profile in a BURST are summarized in a table in the analysis program giving the individual columns for Measured, Surface Correction, Bottom Correction and Total Dissipation and the weight ascribed to each profile based on the portion of variance actually measured. The average dissipation for the BURST is calculated based on a weighted mean and a corresponding weighted Standard Error of the Mean is calculated. These are the values (IntEPS) and errors (ErrEPS) that appear in the data summary.

## MERGING MICROSTRUCTURE AND MEAN CURRENT MEASUREMENTS

The estimation of mean current speed and direction data used to compare with the turbulence measurements is discussed above. The current data files consist of the north and east components of current derived from Aanderaa RCMs and an Ametek Straza ADCP merged in depth and averaged to give half hourly estimates. As well, the depth averaged currents, $U_{AVG}$ and $V_{AVG}$. were obtained by integrating each component and forming the depth averaged rate from the vector sum of these two.

The time of the burst average EPSONDE station does not in general correspond to a half hourly time for the current data base. The current used for inter comparison with the dissipation was obtained from a linear interpolation based on time between the depth averaged currents, $U_{AVG}$ and $V_{AVG}$. and forming the depth averaged rate from the vector sum of these two.

## THE DESCRIPTION OF THE DATA FOR EACH ANCHOR STATION

In the sections to follow the data from each anchor station are presented in a common format. This section will present a detailed summary of the contents of the presentation.

1. Anchor station Title Page:

    -The anchor station coded as above SITE(1..6)(A..C)(23 or 36) corresponding respectively to the site 1 to 6, the sequential anchor station at that site, A to C, and either 23 for cruise 88023 or 36 for cruise 88036.

    -A Table which lists

        -The EPSONDE station (eg E27) which is the burst of profiles that occurred during a period of approximately 1 hour.

        -TimeEPS is the EPSONDE station mean time, in decimal year day.

        -Depth is the maximum depth, meters, of the microstructure sensors that was achieved during the station. While there is some depth variation in the bottom as the ship moves around its anchor during a tidal cycle, the instrument may not always have reached the bottom.

        -Drops is the number of good profiles in a station.

        -Current, is the DEPTH AVERAGED RATE, meters/sec., (the vector sum of $U_{AVG}$ and $V_{AVG}$) obtained from a composite of current meters and Ametek Straza shipboard doppler profiler. The current was measured at half hour intervals and has been interpolated to the EPSONDE times, TimeEPS.

-IntEPS is the dissipation, Watts/$m^2$, which is integrated from the surface to the bottom.

-ErrEPS is the error, Watts/$m^2$, in the integrated dissipation. A complete discussion of IntEPS and ErrEPS is given above.

2. A summary figure of currents and dissipations which has three panels:

   -Panel A is a current vector plot for the mid-depth current meter at the mooring site. It overlaps the time period of the anchor station which is indicated below.

   -Panel B shows the half hourly magnitude of the DEPTH AVERAGED RATE along with the half hour averaged northward rate, $U_{AVG}$.

   -Panel C shows the DEPTH AVERAGED RATE interpolated to EPSONDE station times (Current at TimeEPS from the table above) on the axis at the left. The integrated dissipation (IntEPS from the Table above) and the errors (IntEPS $\pm$ ErrEPS) are shown on the same panel with the axis on the right.

3. A Figure with a page for each of the STATIONS shown in the precedingTable. The cover page for this Figure lists all of the Stations included and the alphabetical sequence number for each Station. Each STATION page has a common format. There are four panels per page:

   -CHI-THETA is the dissipation of temperature fluctuations, $\chi_\theta$ [$^oC^2/s$]

   -VERT DIFFUSIVITY contains two measures of vertical diffusivity,

   $K_T$ and $K_\rho$ [$m^2/s$]

   -DISSIPATION is profile of viscous dissipation, $\varepsilon$ [$m^2/s^3$]

   -COX NUMBER is the profile of Cox Number.

   Every panel has a the last temperature profile of the BURST superimposed. Each panel represents the BURST average of data which has been averaged into 5 meter vertical bins.

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# SITE 1A23

42°09.23N, 66°47.88W

TABLE 1: COMBINED CURRENT AND DISSIPATION

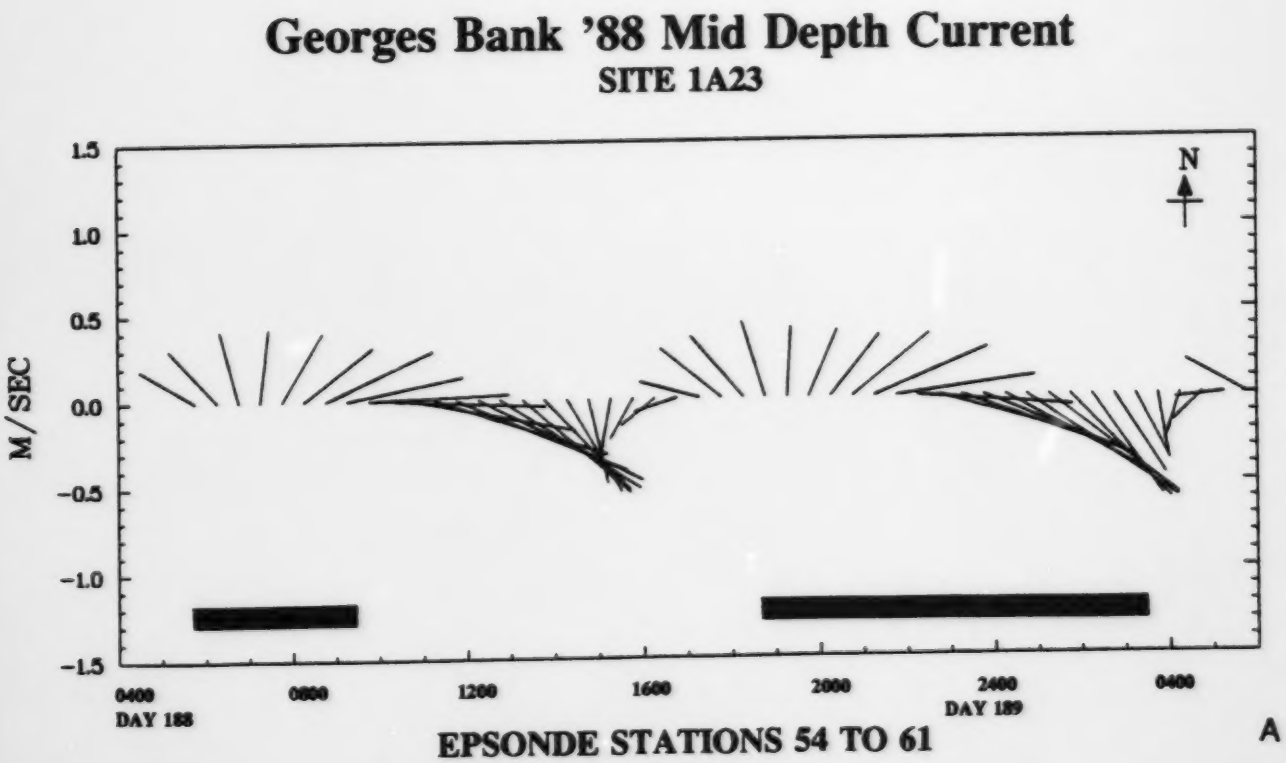
| Station | TimeEPS | Depth | Drops | Current | IntEPS | ErrEPS |
|---|---|---|---|---|---|---|
| E540105 | 188.2444 | 110.65 | 5 | 0.482 | 0.1105 | 0.0192 |
| E540610 | 188.2649 | 107.00 | 5 | 0.456 | 0.1326 | 0.0177 |
| E541115 | 188.2917 | 112.35 | 5 | 0.412 | 0.2057 | 0.0156 |
| E541620 | 188.3139 | 110.25 | 5 | 0.396 | 0.1156 | 0.0214 |
| E542125 | 188.3344 | 111.50 | 5 | 0.379 | 0.0945 | 0.0210 |
| E542630 | 188.3552 | 106.60 | 5 | 0.384 | 0.0521 | 0.0095 |
| E543135 | 188.3767 | 103.25 | 5 | 0.426 | 0.0222 | 0.0083 |
| E543640 | 188.3983 | 108.55 | 5 | 0.491 | 0.0166 | 0.0052 |
| E55 | 188.8076 | 120.00 | 8 | 0.378 | 0.3019 | 0.0417 |
| E56 | 188.8594 | 115.25 | 8 | 0.371 | 0.0660 | 0.0074 |
| E57 | 188.9076 | 112.75 | 8 | 0.470 | 0.0356 | 0.0162 |
| E58 | 188.9622 | 104.65 | 8 | 0.597 | 0.0065 | 0.0010 |
| E59 | 189.0264 | 107.20 | 8 | 0.692 | 0.0012 | 0.0006 |
| E60 | 189.0885 | 109.20 | 8 | 0.477 | 0.0375 | 0.0066 |
| E61 | 189.1469 | 110.95 | 4 | 0.150 | 0.0072 | 0.0008 |

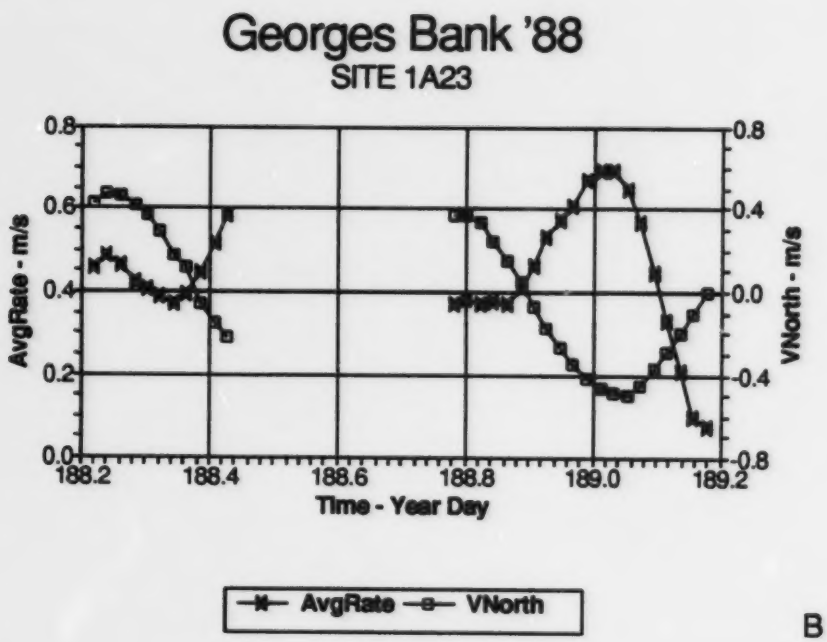
FIGURE 4:

A. Current vector plot for the RCM at 43m depth at site 1 overlapping the EPSONDE anchor station 1A during cruise 88023 (1A23). This anchor station includes EPSONDE stations 54 to 61.

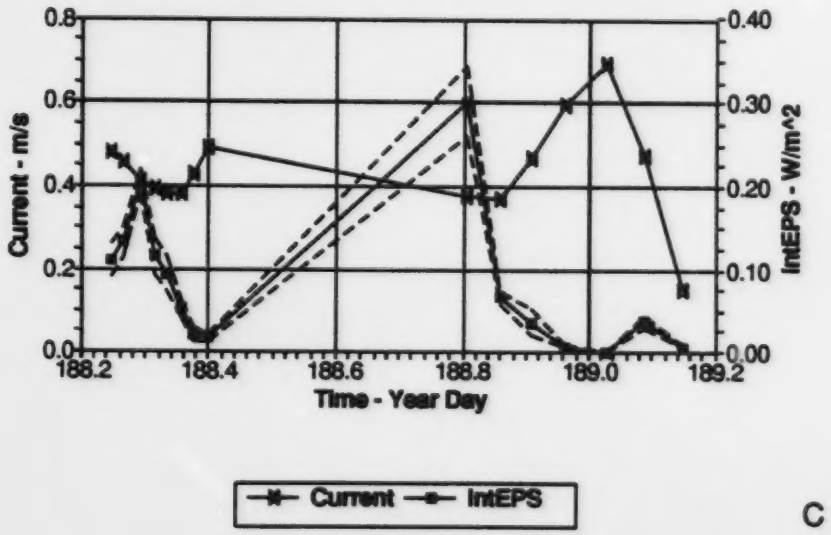
B. The magnitude and the northward component of the vertically averaged composite RCM and Ametek DCP current at half hourly intervals for site 1 coincident with EPSONDE anchor station 1A23.

C. The magnitude of the vertically averaged composite current interpolated to the mean EPSONDE station time and the integrated dissipation, IntEPS, for each EPSONDE station during anchor station 1A23. Error limits are indicated for IntEPS.




Georges Bank '88
SITE 1A23
AvgRate - m/s
VNorth - m/s
Time - Year Day
AvgRate
VNorth

B

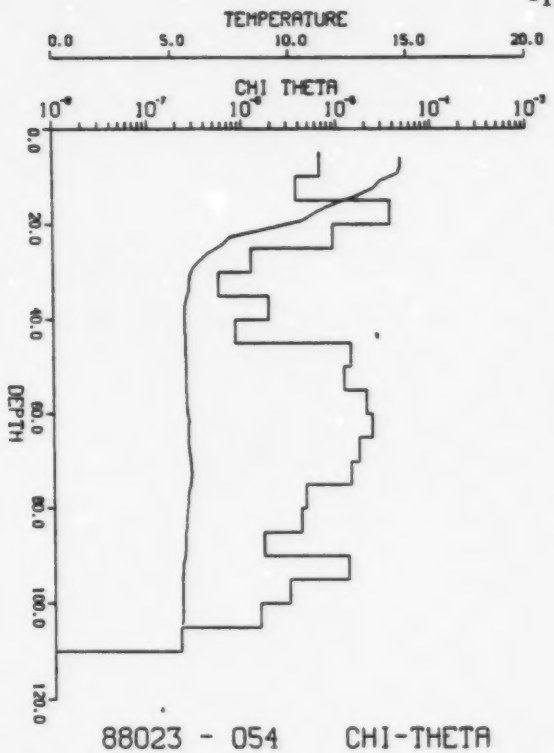

Microstructure Anchor Station
SITE 1A23
Current - m/s
IntEPS - W/m^2
Time - Year Day
Current
IntEPS

C

FIGURE 5: Profiles of microstructure quantities for stations 54 to 61 for anchor station 1A23.
- Each page contains a profile of a microstructure quantity averaged over 5 m vertical bins overlaid on a profile of temperature.
- The upper left panel is Chi-Theta, the dissipation of temperature variance.
- The upper right panel contains profiles of vertical diffusivity KT (for temperature) and KRHO for density.
- The lower left panel contains a profile of dissipation, EPSILON.
- The lower right panel shows the profile for Cox number.

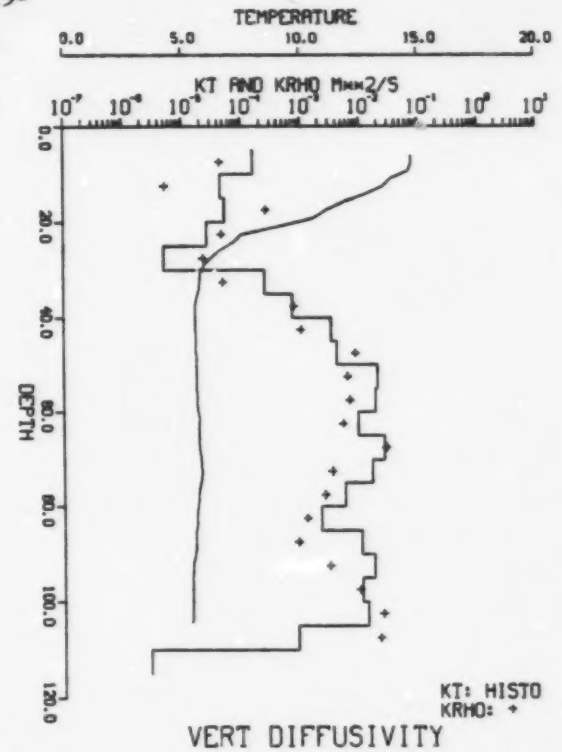
The stations are shown in the following order:

A. Station 54 - profiles 01 to 05
B. Station 54 - profiles 06 to 10
C. Station 54 - profiles 11 to 15
D. Station 54 - profiles 16 to 20
E. Station 54 - profiles 21 to 25
F. Station 54 - profiles 26 to 30
G. Station 54 - profiles 31 to 35
H. Station 54 - profiles 36 to 40
I. Station 55
J. Station 56
K. Station 57
L. Station 58
M. Station 59
N. Station 60
O. Station 61




88023 - 054 CHI-THETA

**1 to 5**

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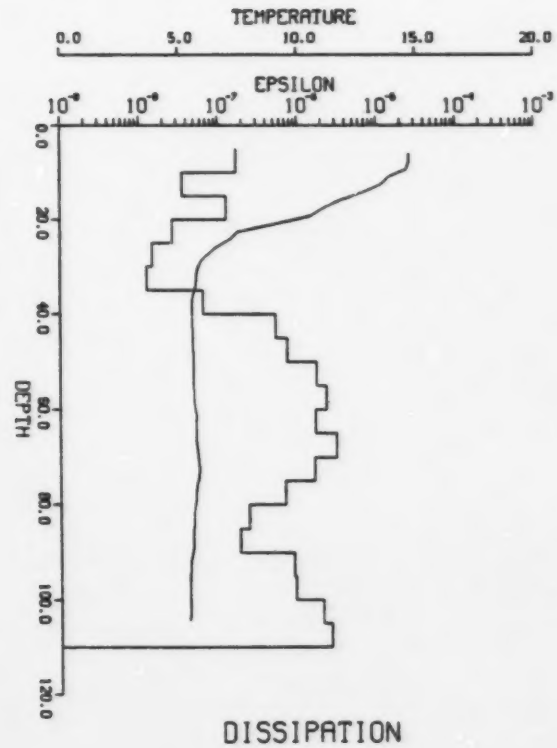


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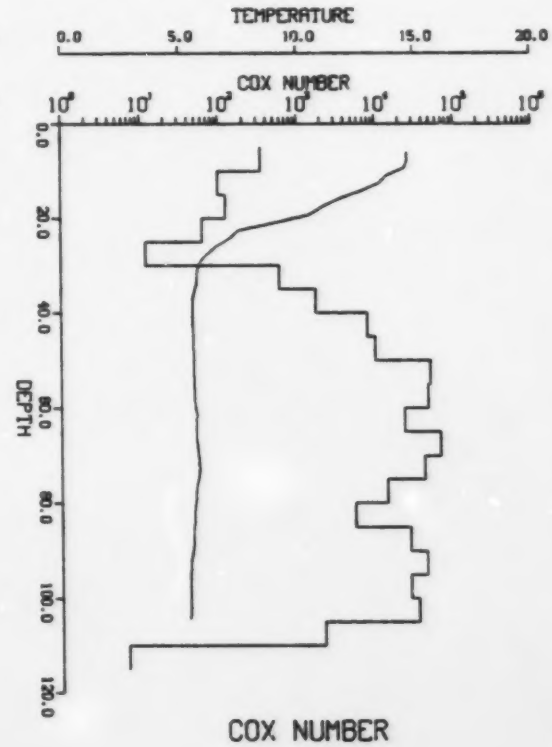


COX NUMBER

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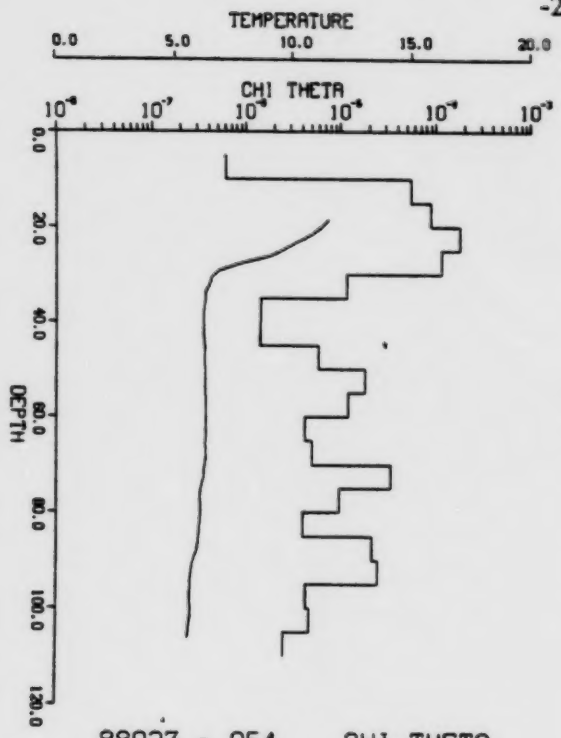


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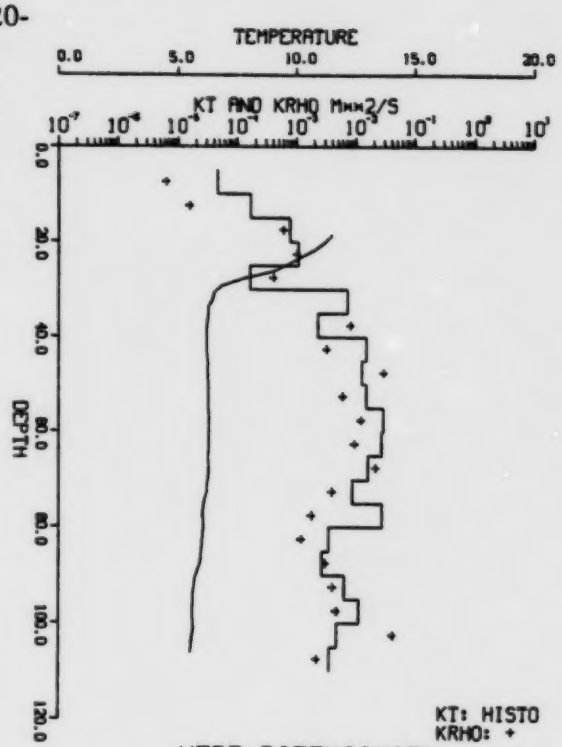
**6 to 10**

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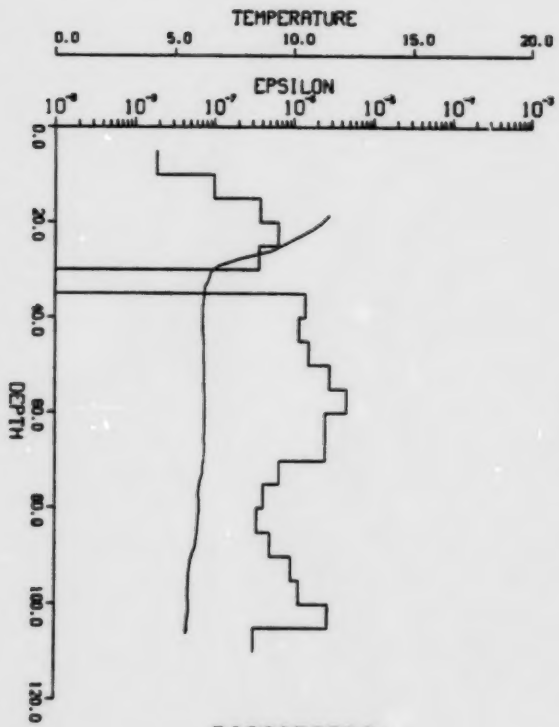


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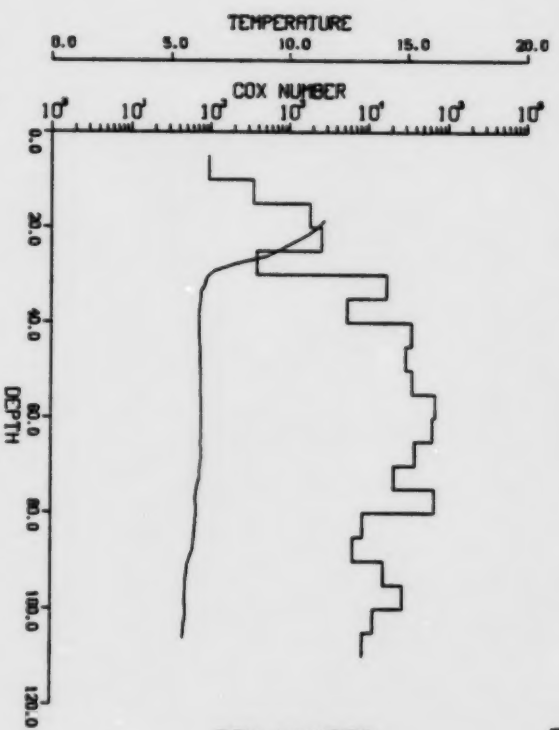


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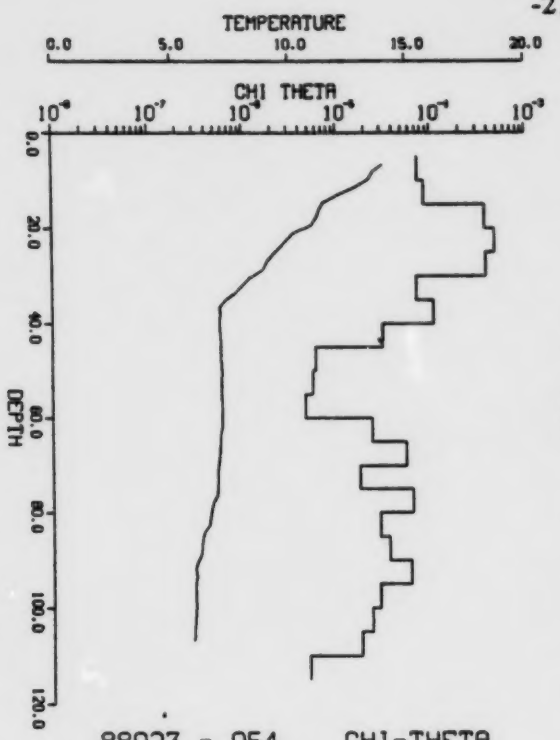


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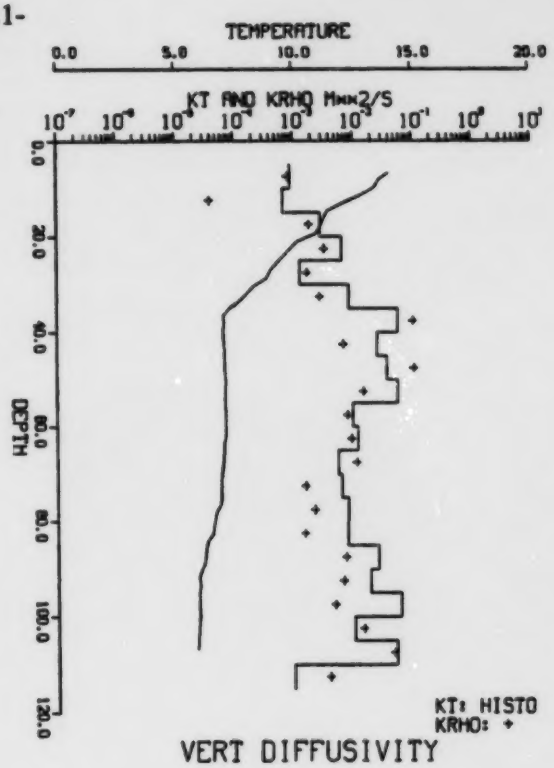
**11 to 15**

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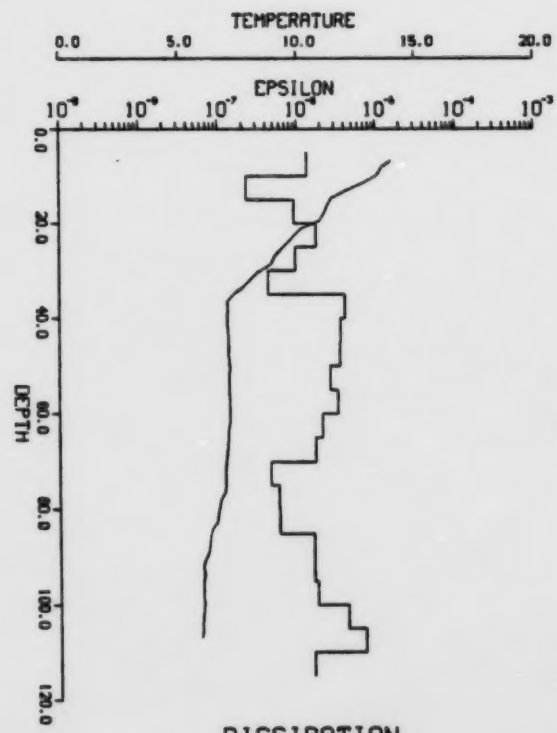


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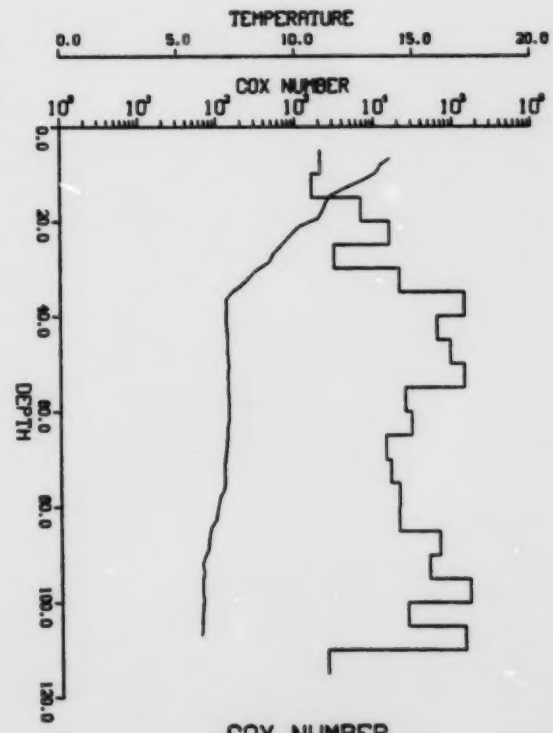


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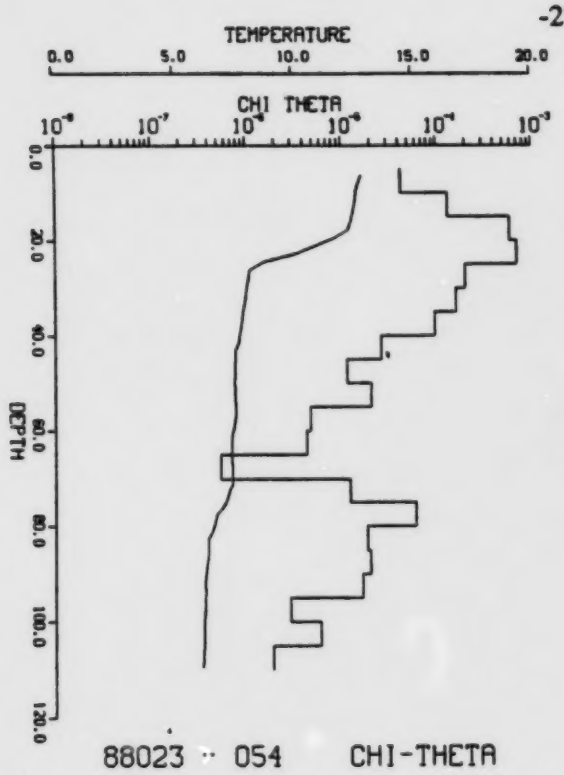


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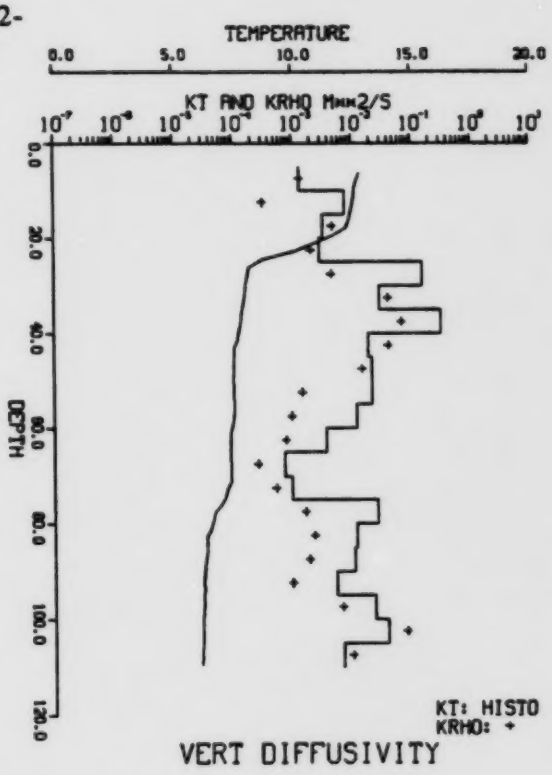


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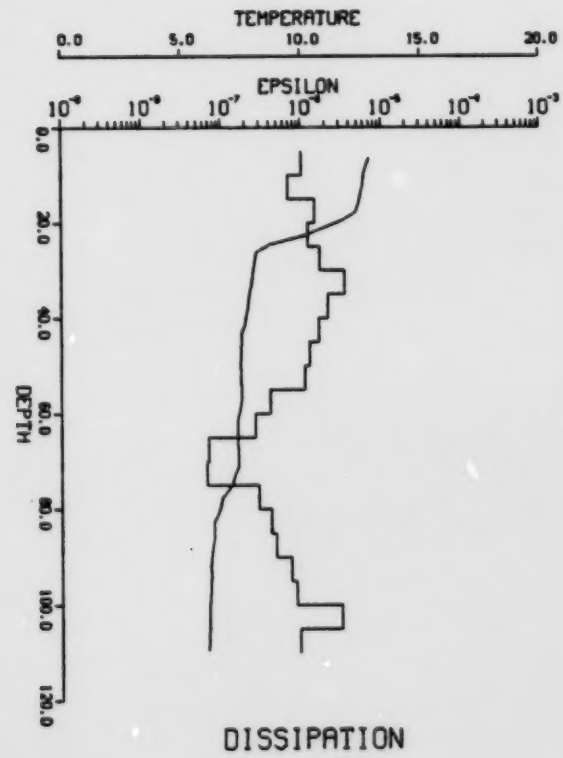
**16 to 20**

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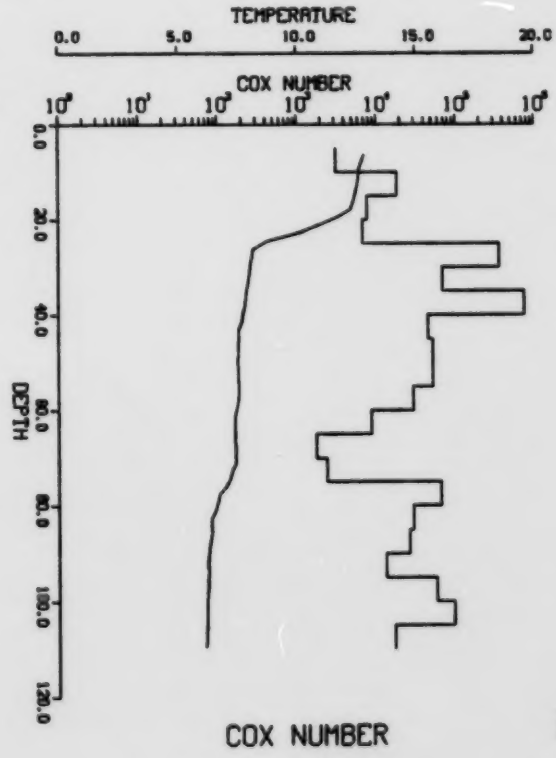


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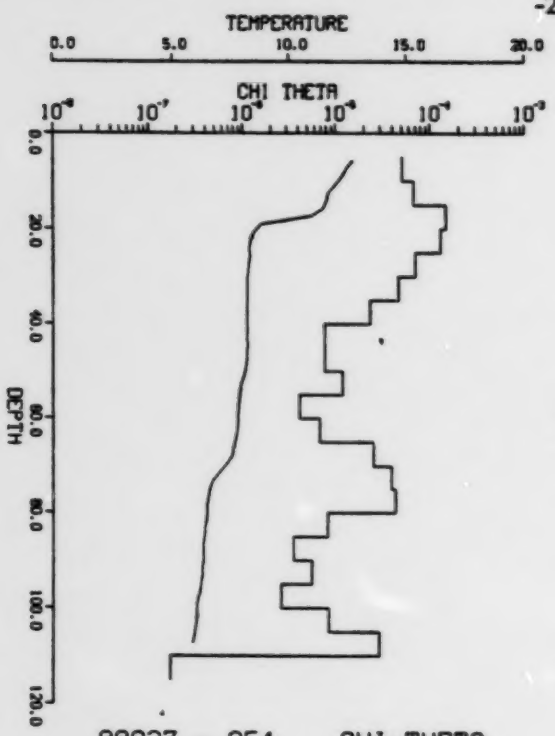


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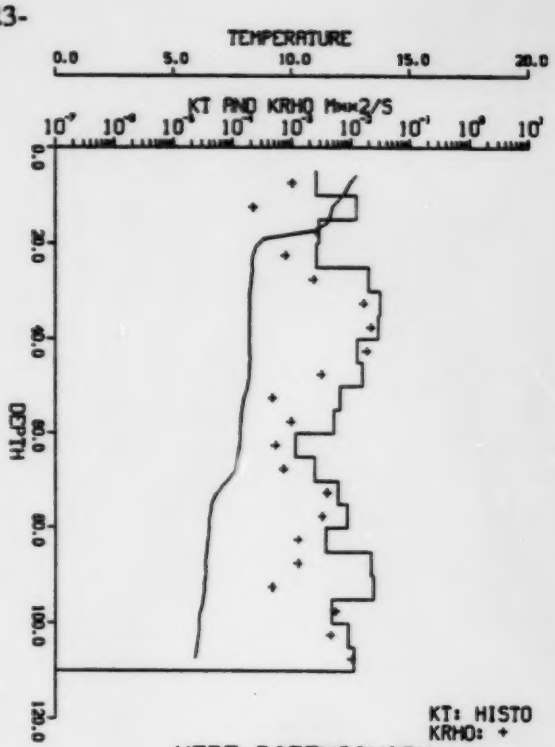
**21 to 25**

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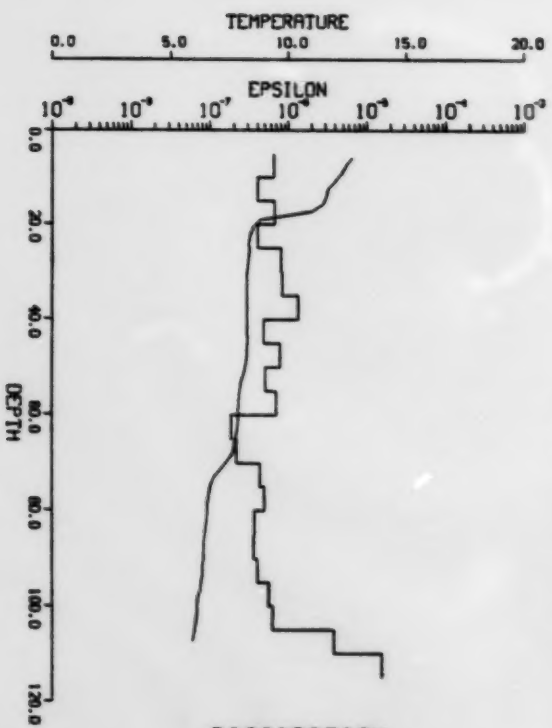


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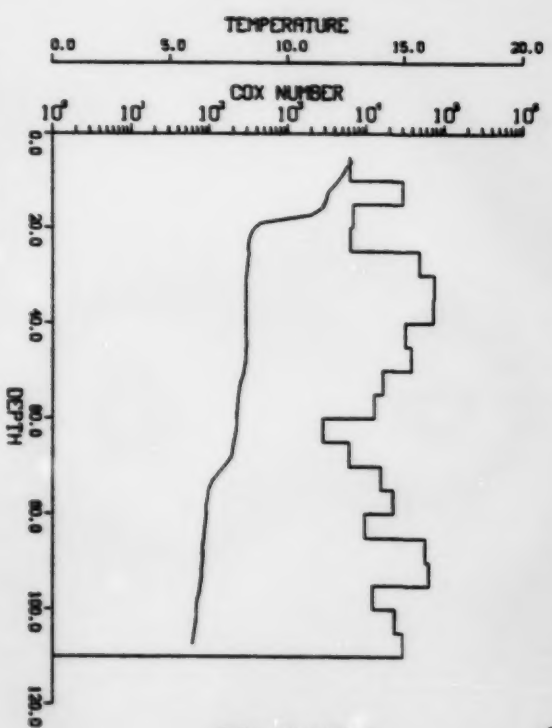


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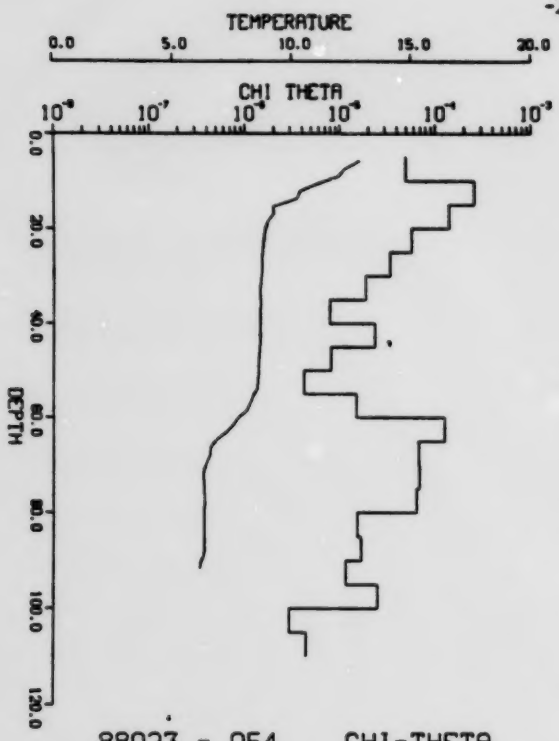


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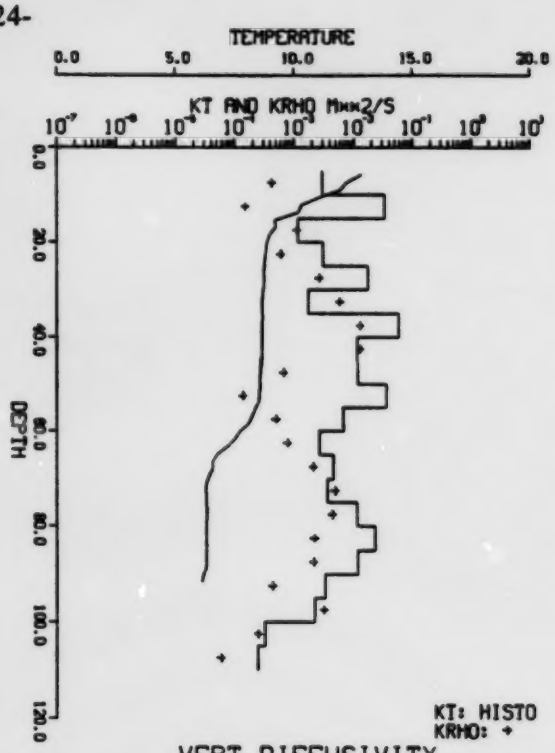


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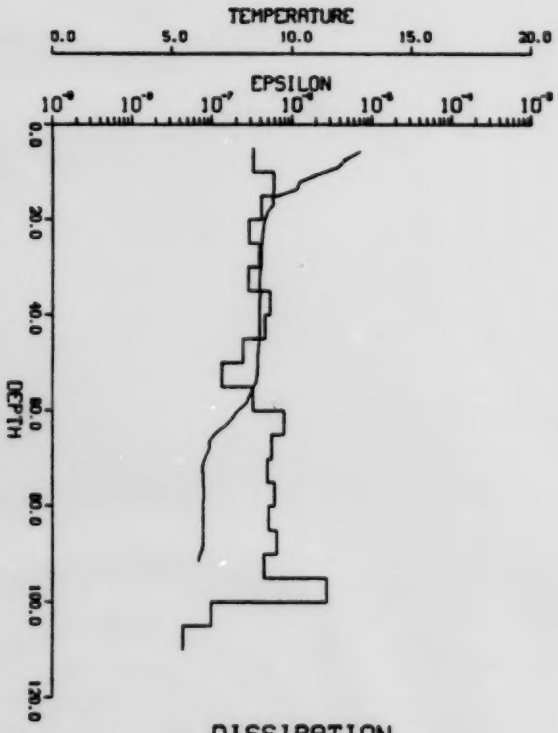


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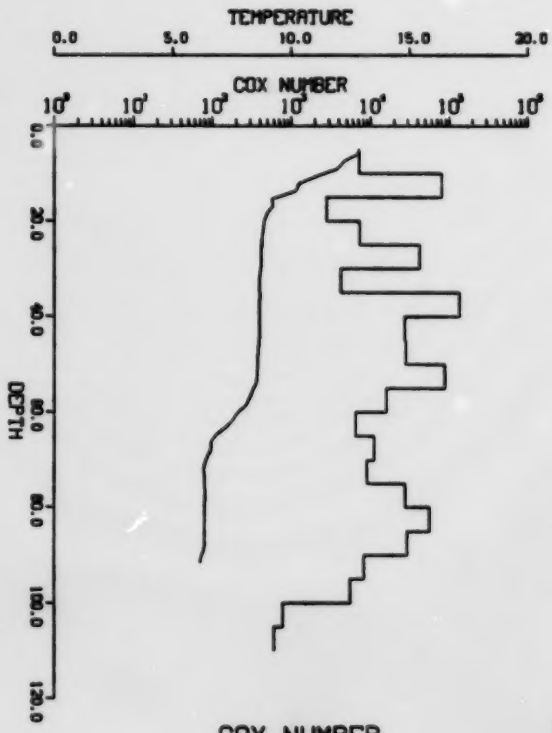


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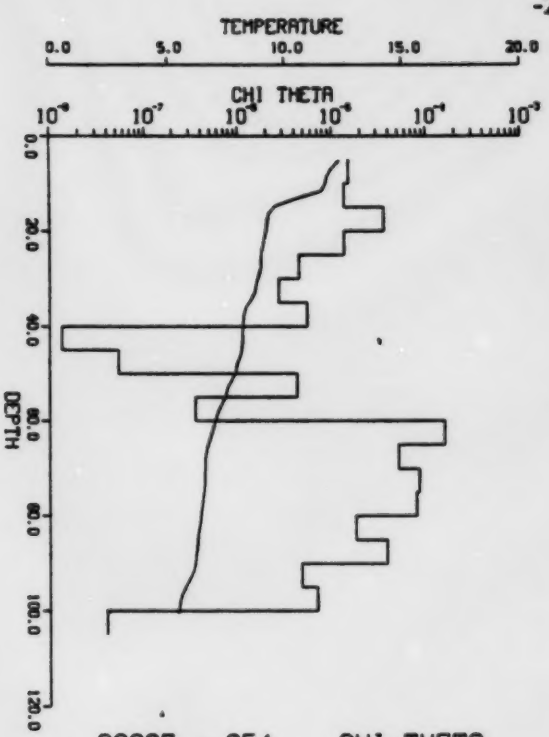


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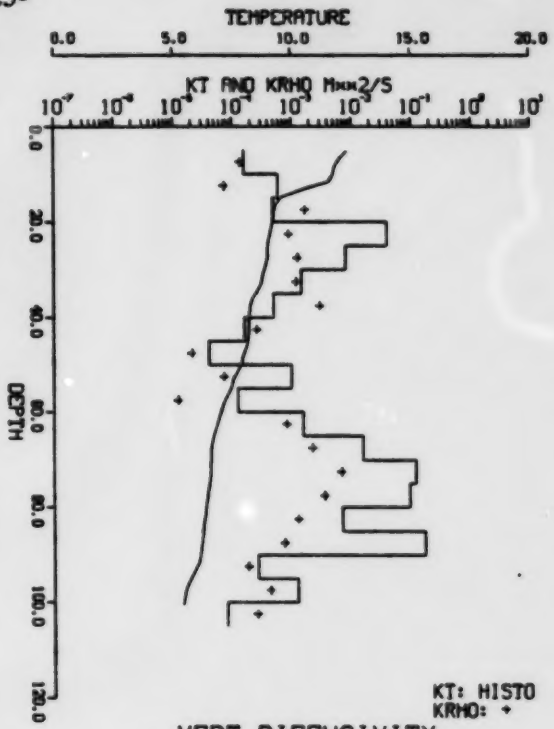


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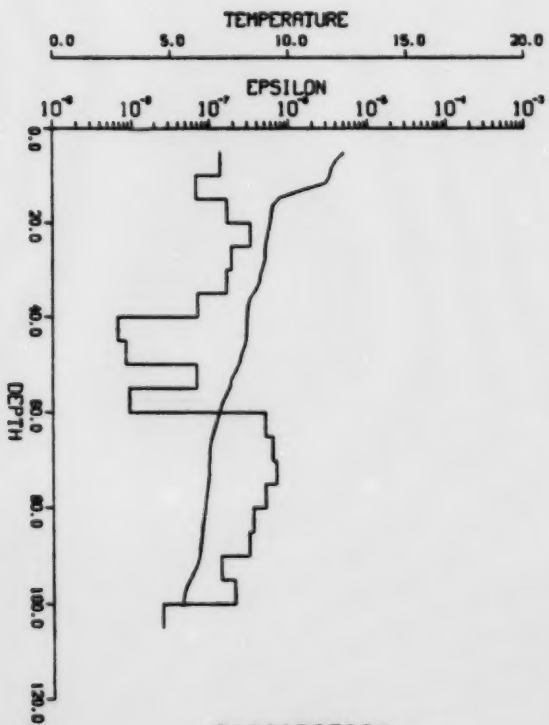


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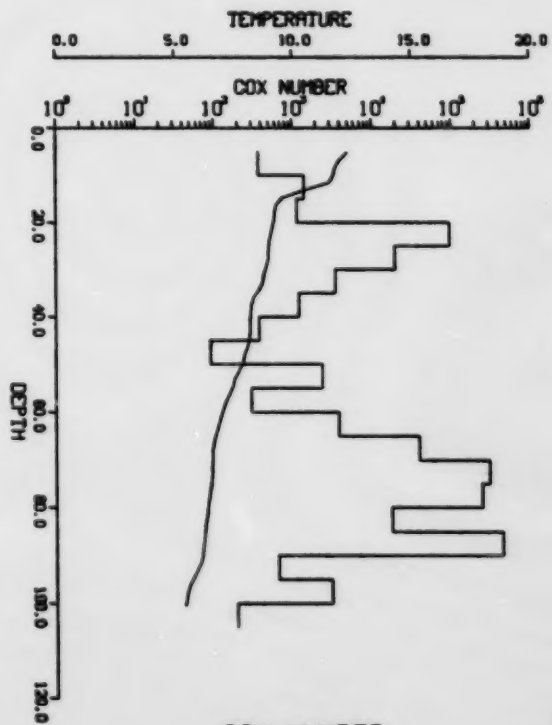


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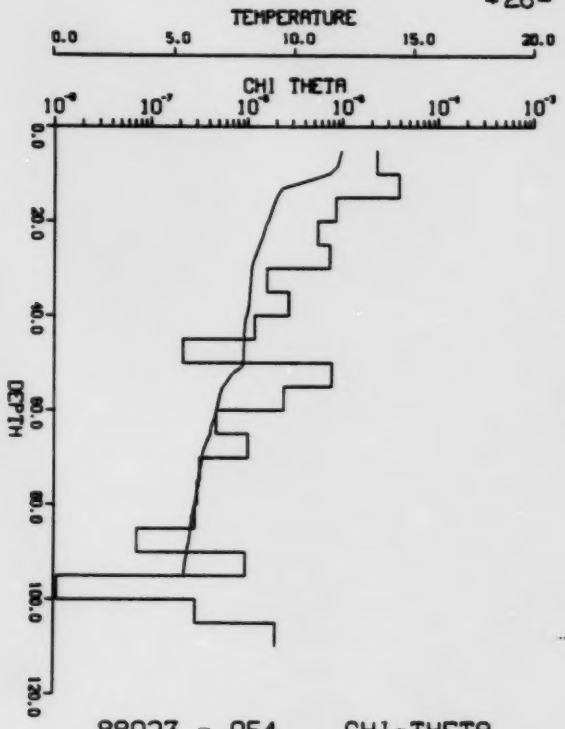


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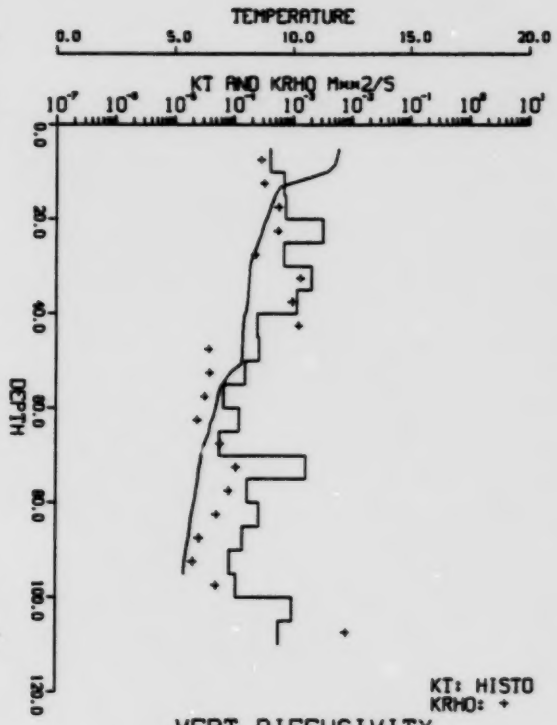
36 to 40

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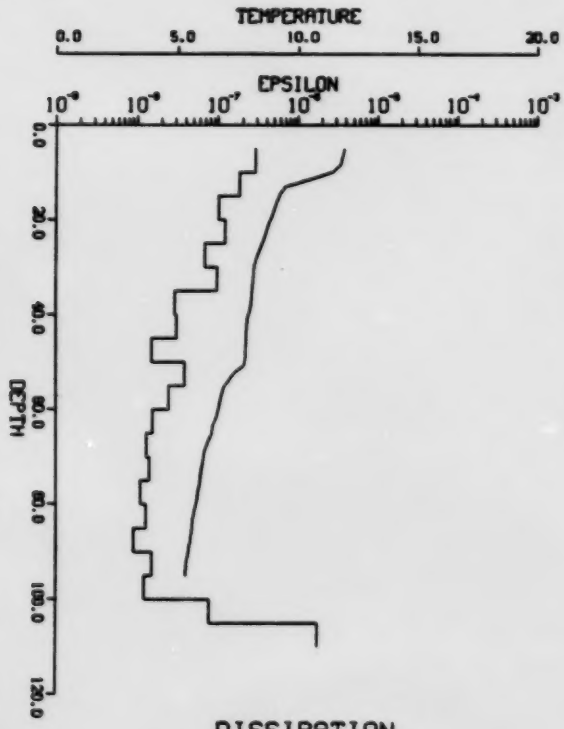


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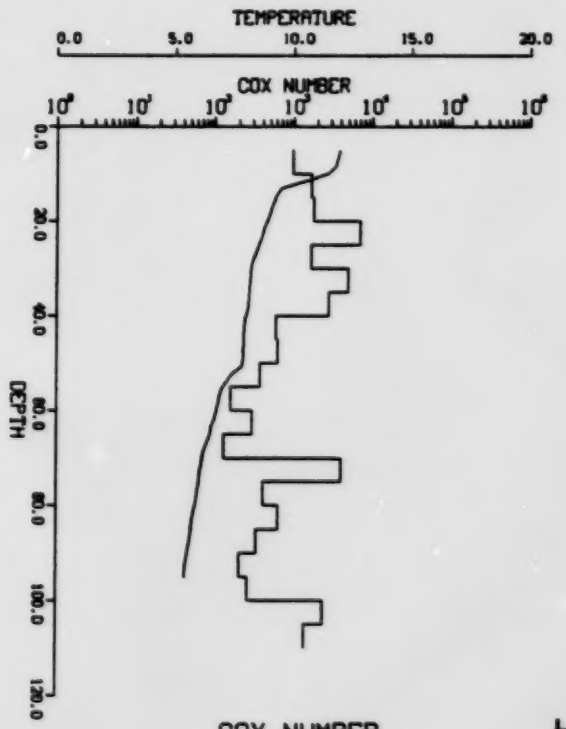


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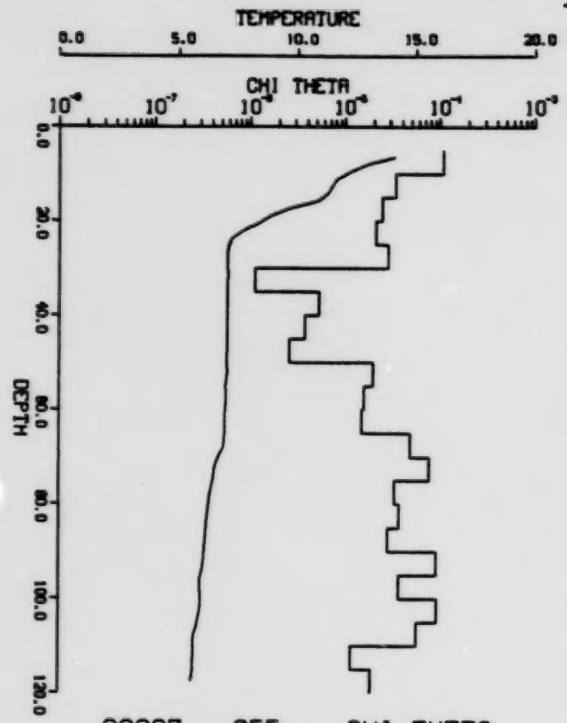


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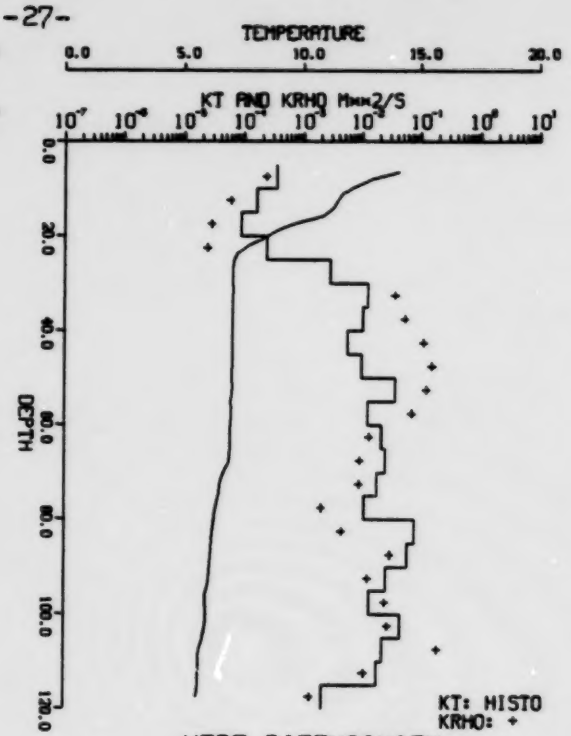


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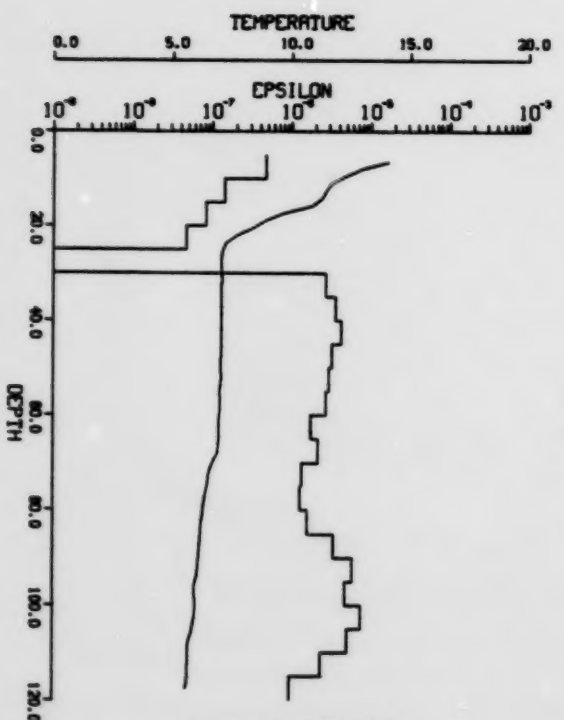


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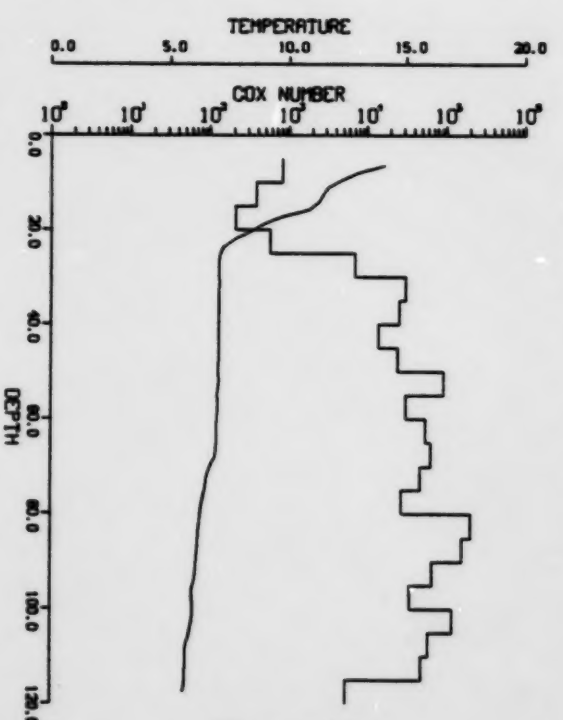


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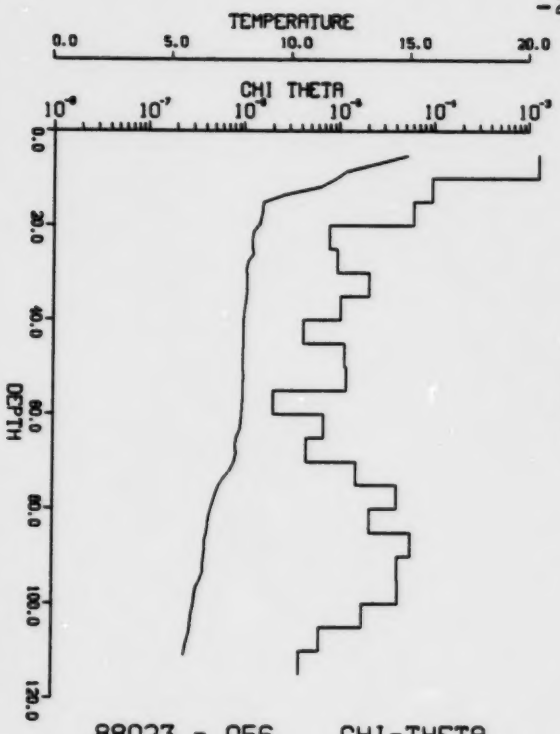
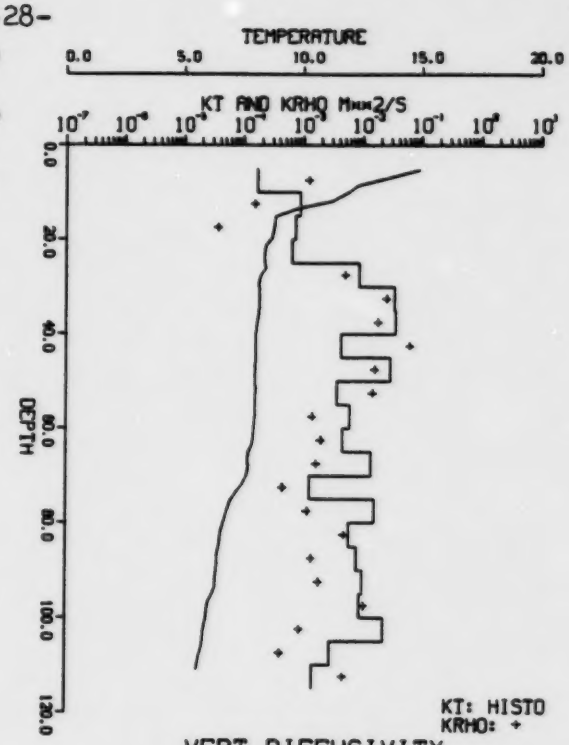



88023 - 056 CHI-THETA

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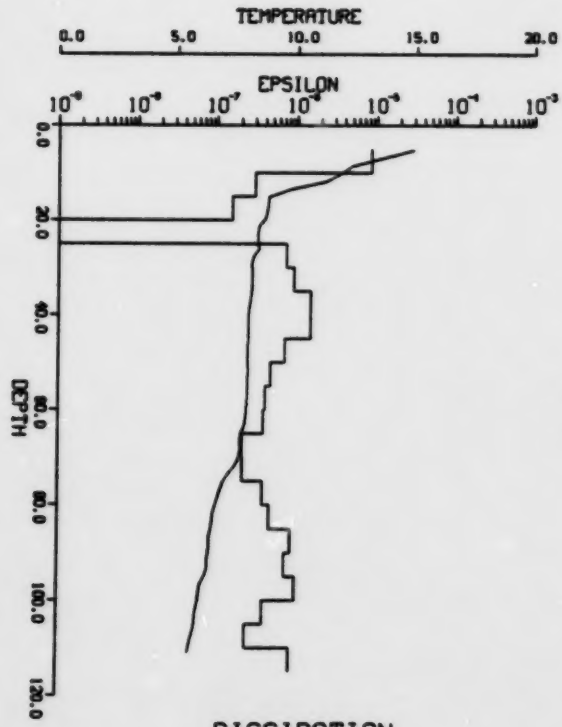


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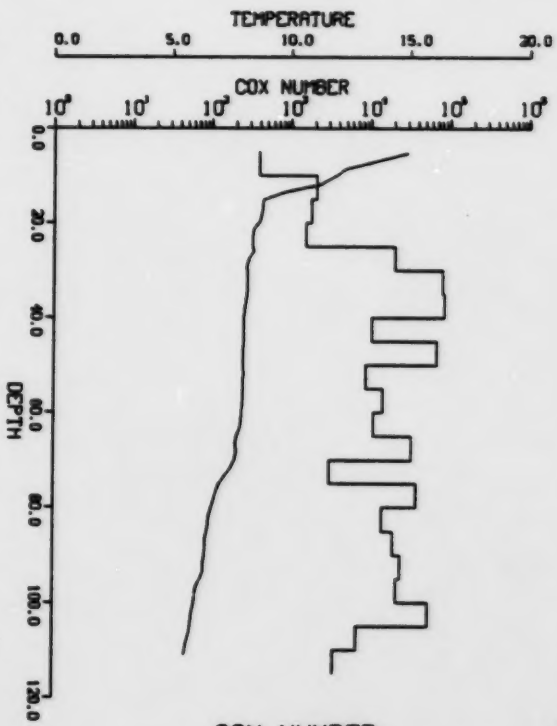


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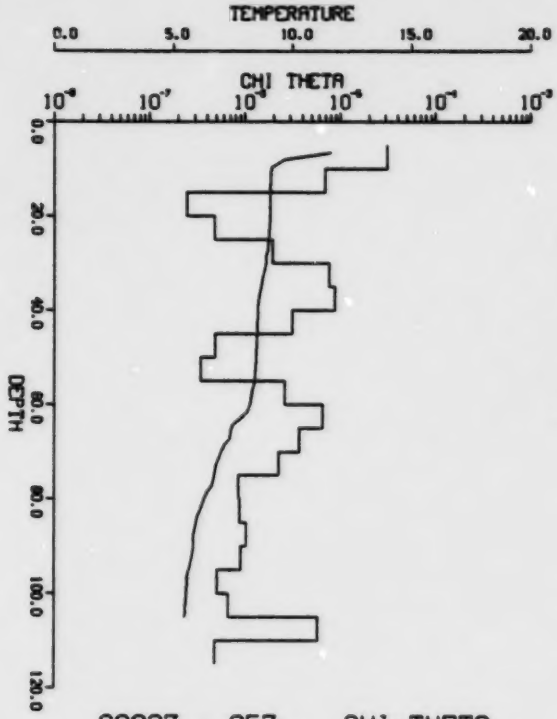
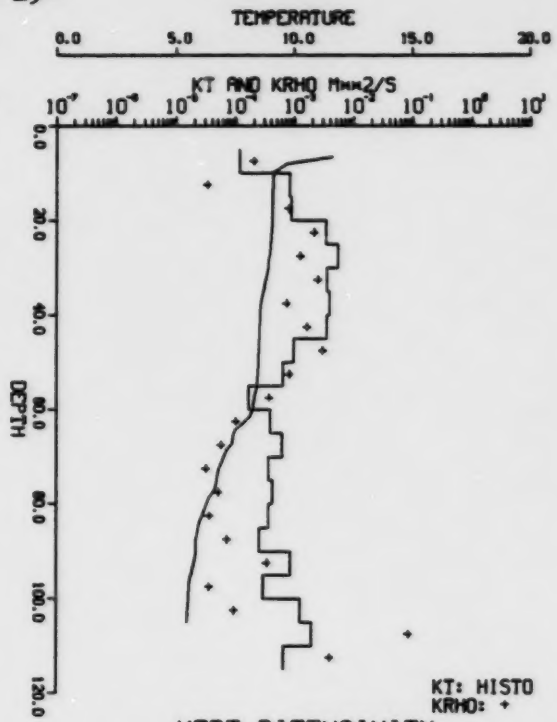



88023 - 057 CHI-THETA

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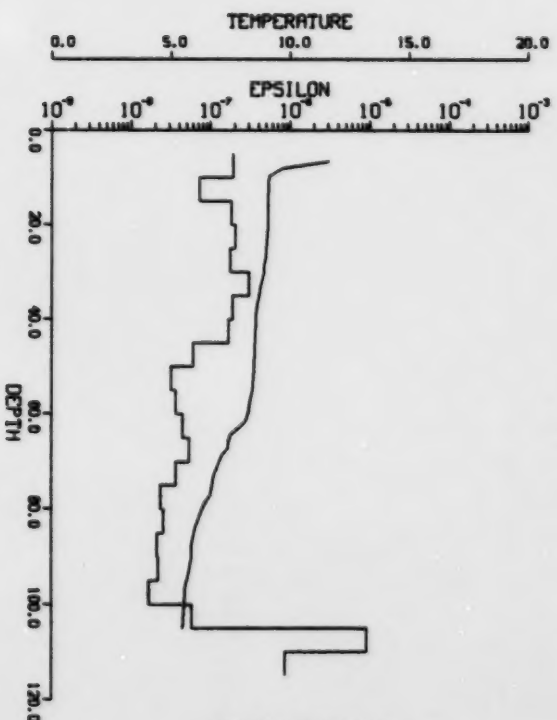


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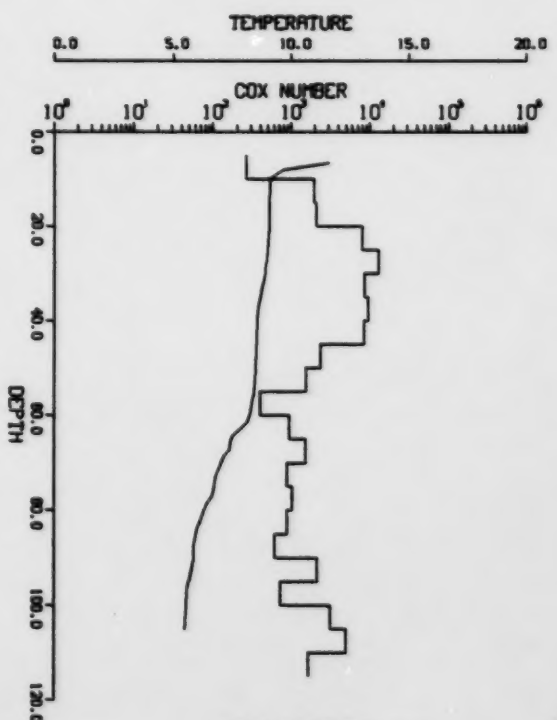


COX NUMBER

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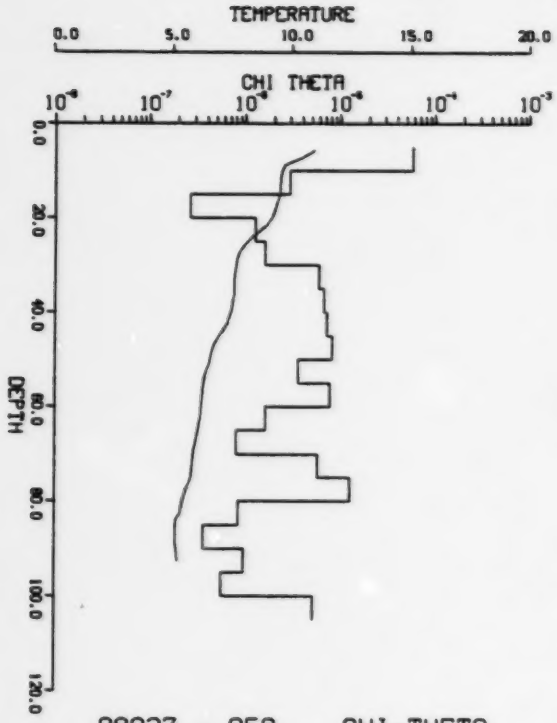
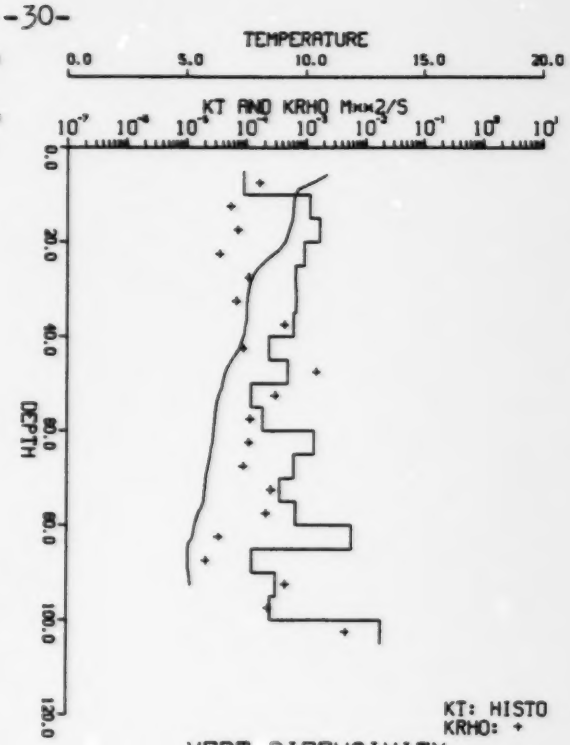



88023 - 058 CHI-THETA

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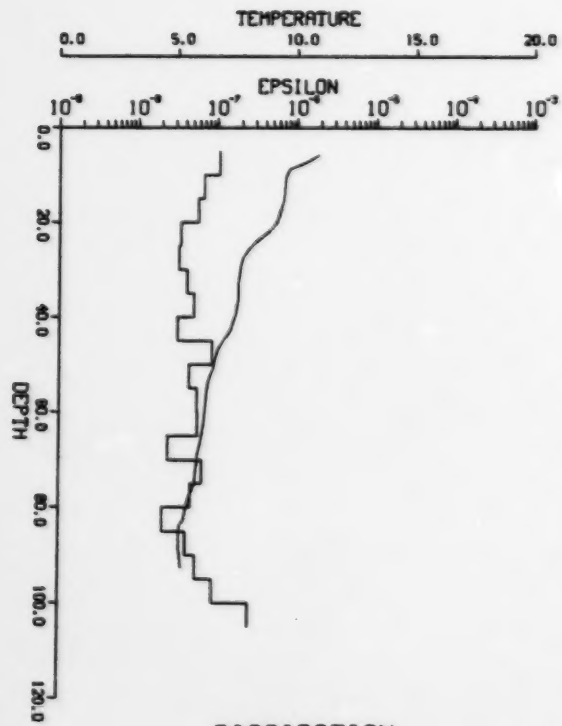


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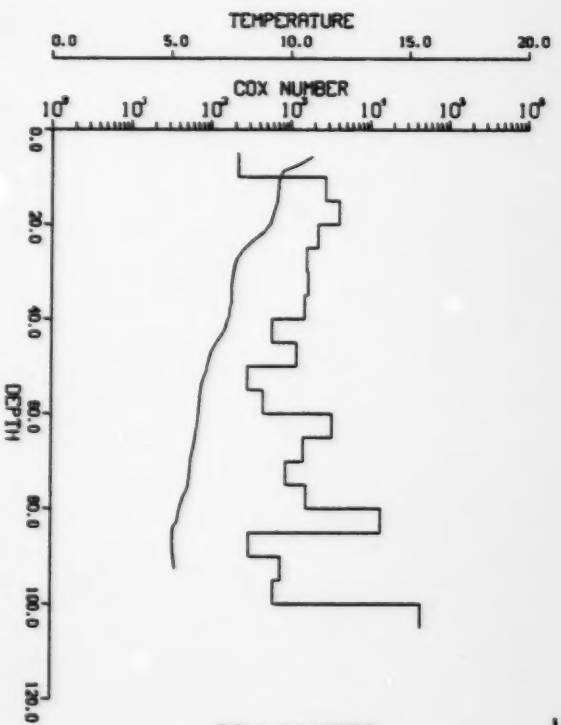


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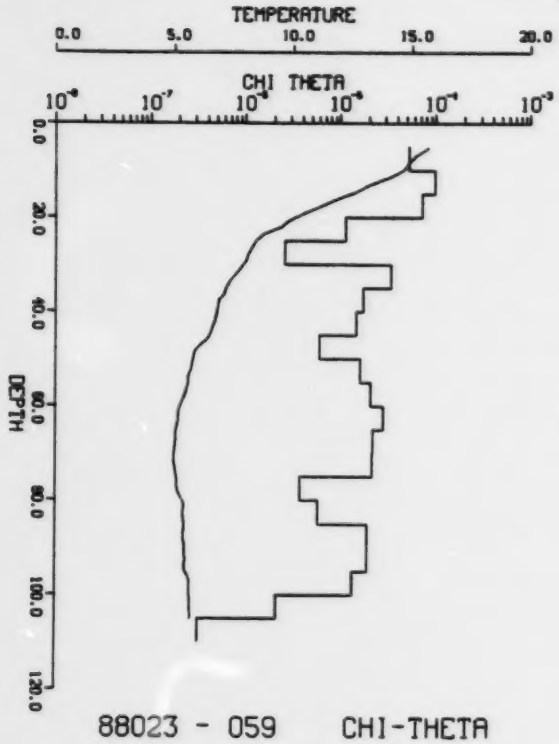
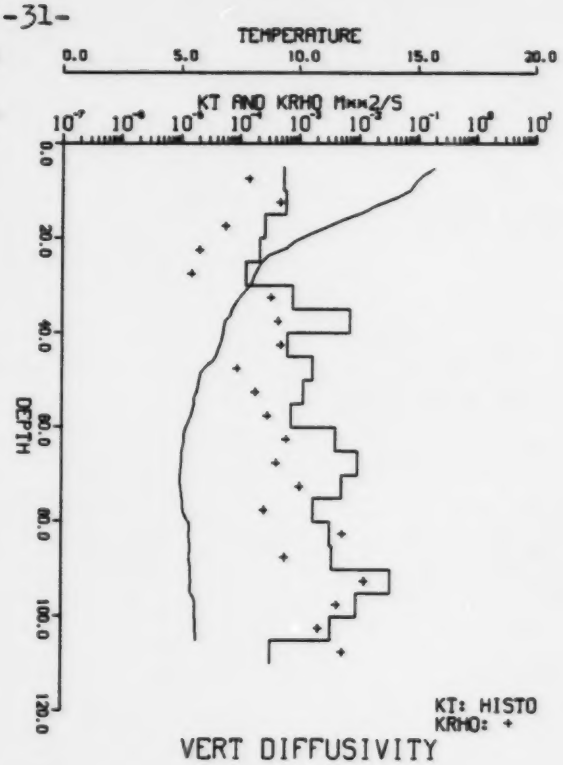



88023 - 059 CHI-THETA

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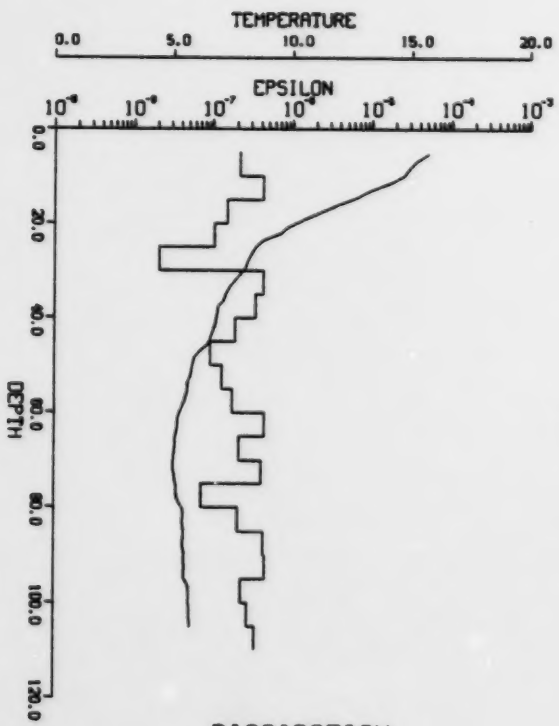


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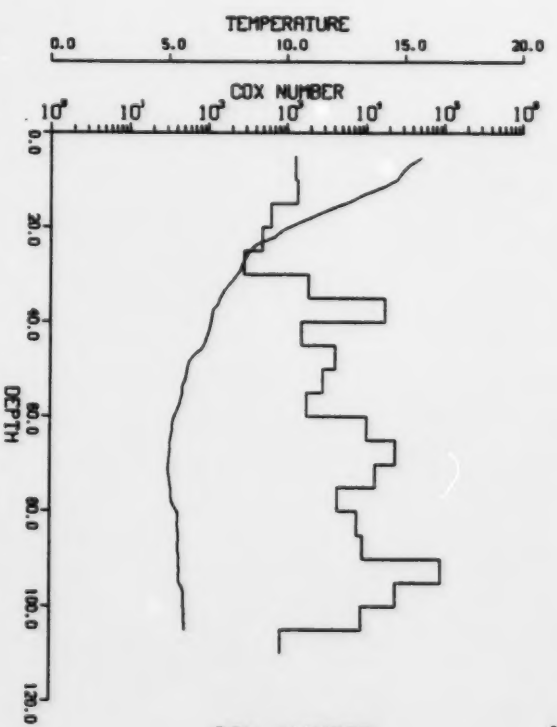


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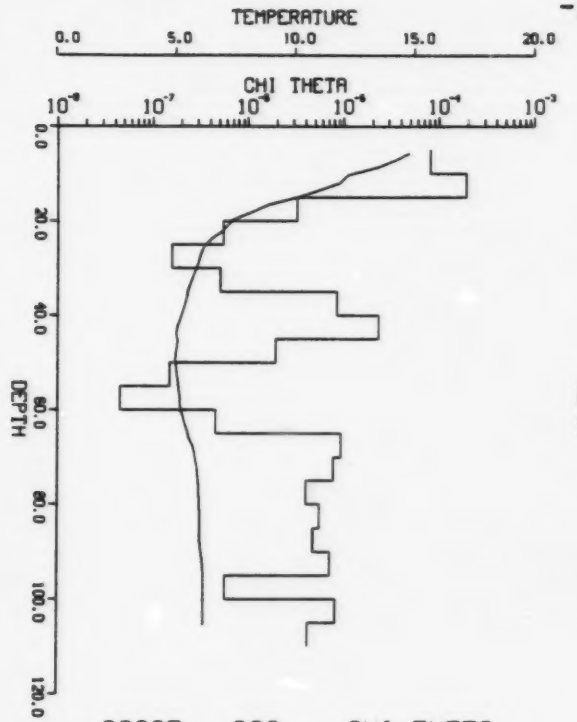
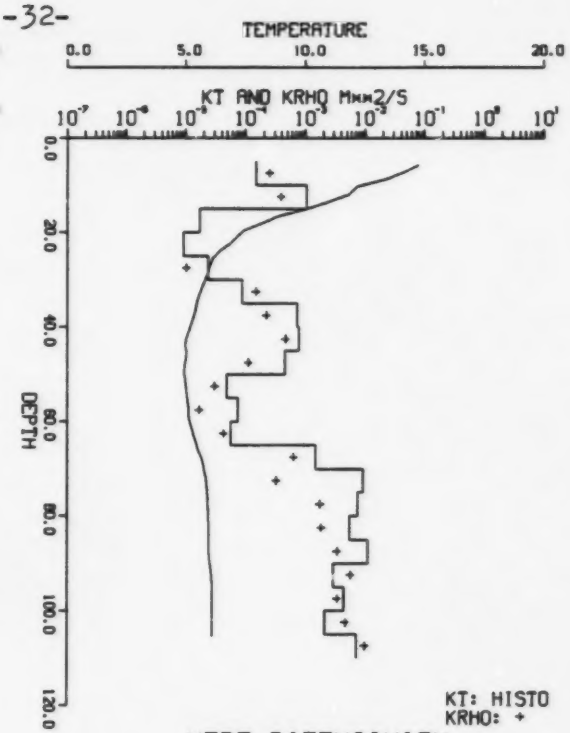



88023 - 060 CHI-THETA

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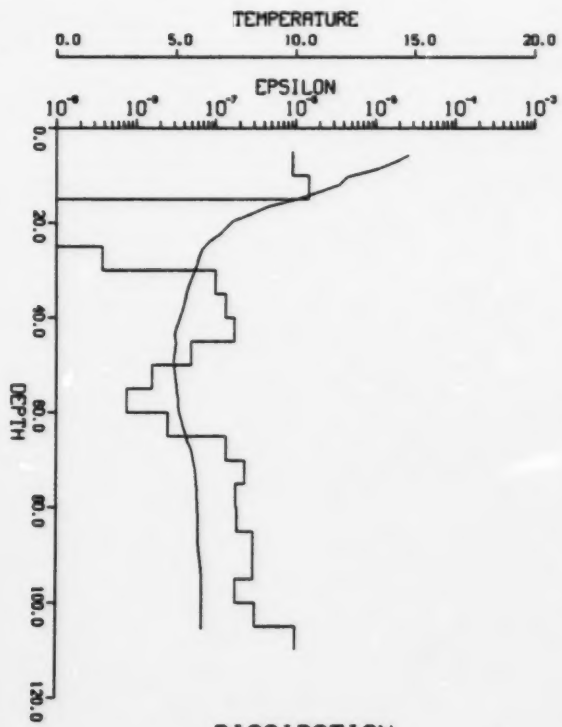


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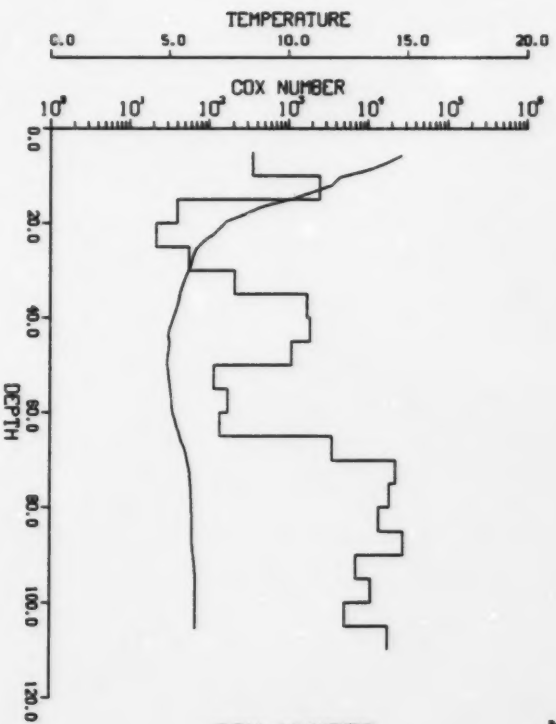


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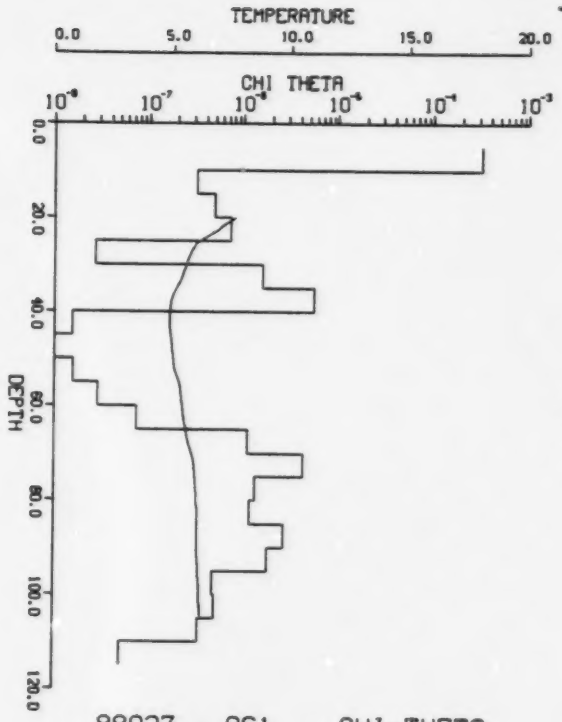
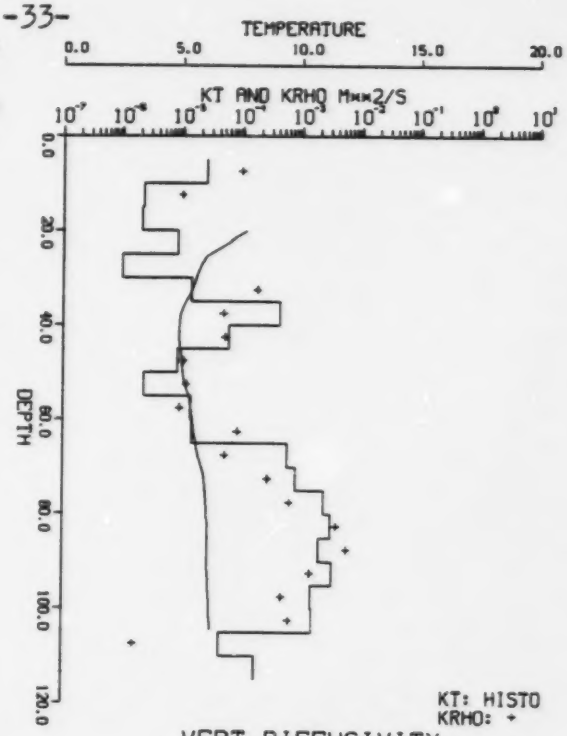



88023 - 061 CHI-THETA

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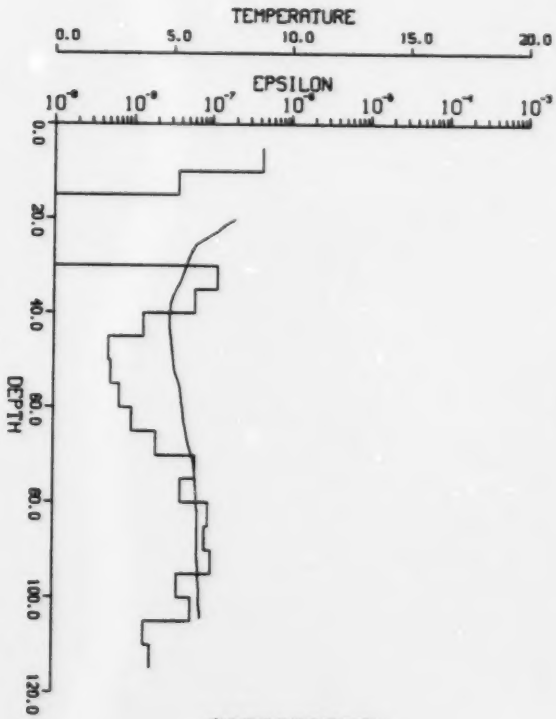


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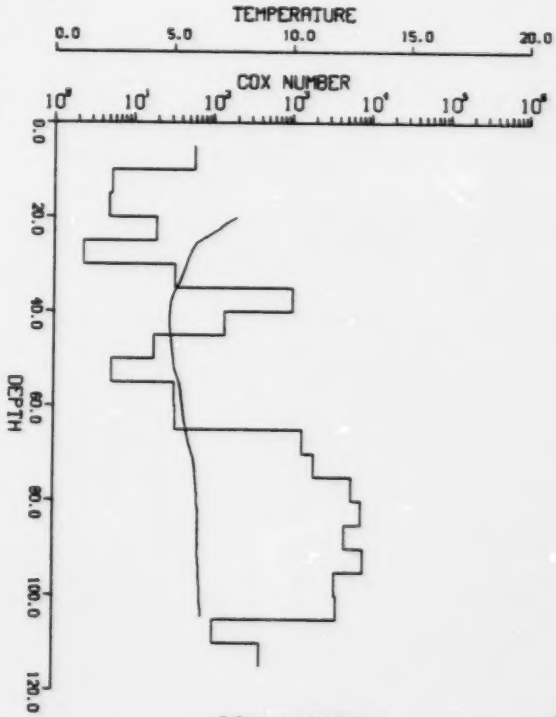



COX NUMBER

# SITE 2B23

42°04.85N, 66°46.66W

TABLE 2: COMBINED CURRENT AND DISSIPATION

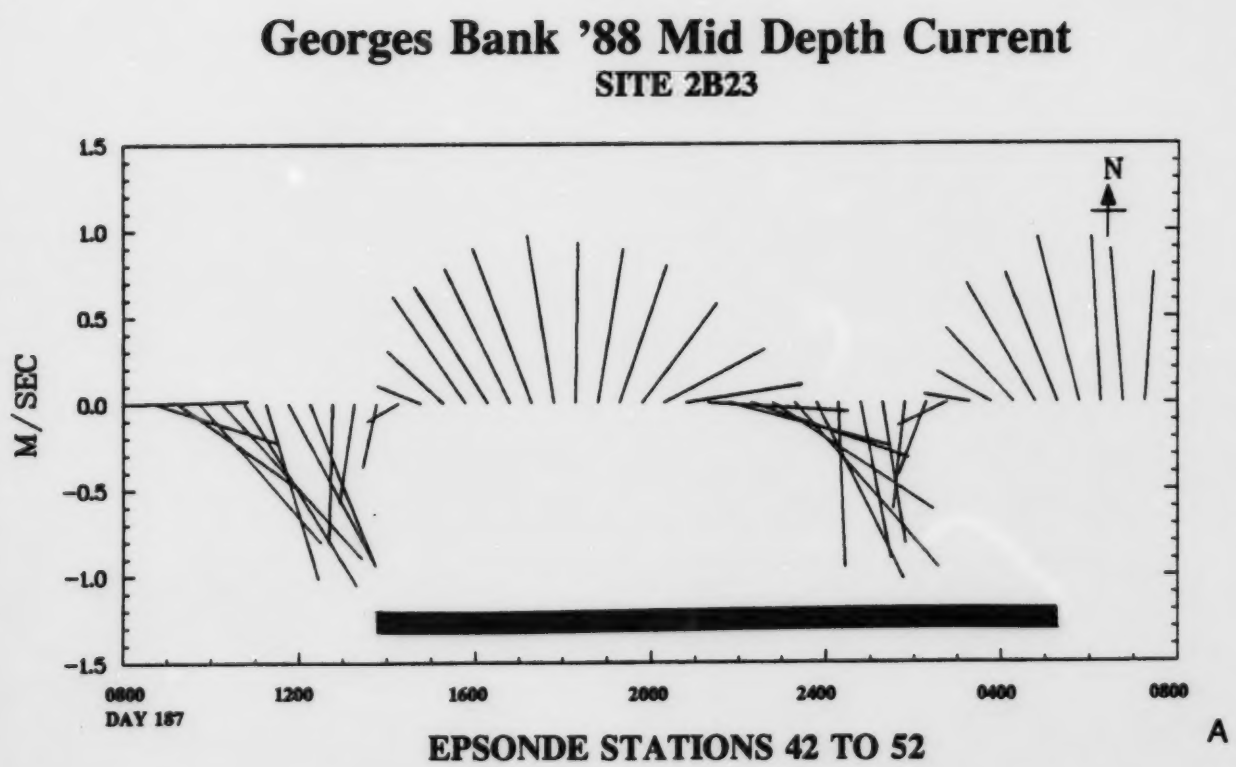
| Station | TimeEPS | Depth | Drops | Current | IntEPS | ErrEPS |
|---|---|---|---|---|---|---|
| E42 | 187.6125 | 66.00 | 7 | 0.217 | 0.0302 | 0.0076 |
| E43 | 187.6528 | 64.80 | 7 | 0.539 | 0.2320 | 0.2175 |
| E44 | 187.6990 | 65.55 | 8 | 0.842 | 0.1246 | 0.0138 |
| E45 | 187.7319 | 64.70 | 1 | 0.907 | 0.1514 | 0.0473 |
| E46 | 187.7924 | 65.30 | 8 | 0.727 | 0.0515 | 0.0059 |
| E47 | 187.8507 | 66.00 | 8 | 0.584 | 0.0545 | 0.0138 |
| E48 | 187.8872 | 66.00 | 8 | 0.719 | 0.0520 | 0.0209 |
| E49 | 187.9281 | 66.00 | 8 | 0.935 | 0.1298 | 0.0239 |
| E50 | 187.9698 | 63.15 | 8 | 1.101 | 0.2088 | 0.0556 |
| E51 | 188.0264 | 63.55 | 8 | 1.005 | 0.0114 | 0.0029 |
| E52 | 188.0813 | 65.00 | 6 | 0.585 | 0.0618 | 0.0147 |

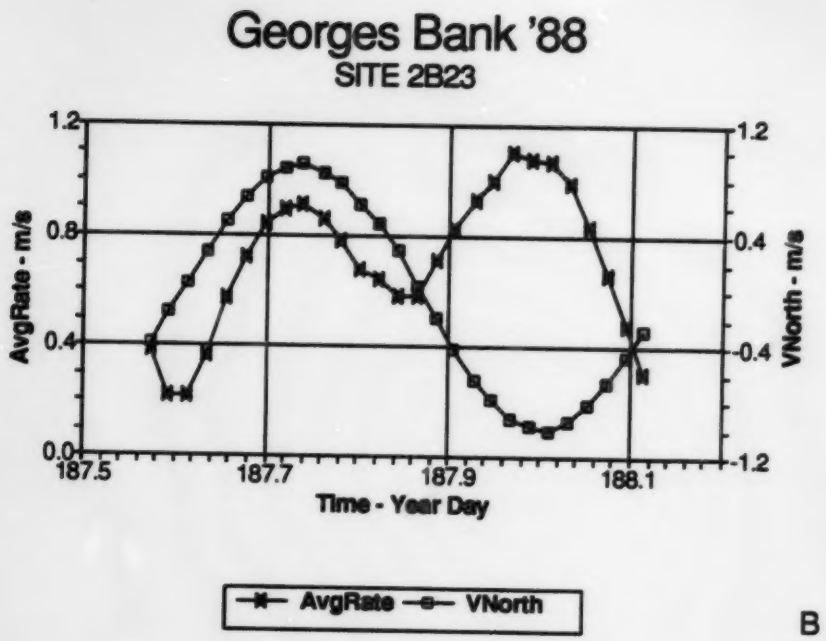
FIGURE 6:

A. Current vector plot for the RCM at 35m depth at site 2 overlapping the EPSONDE anchor station 2B during cruise 88023 (2B23). This anchor station includes EPSONDE stations 42 to 52.

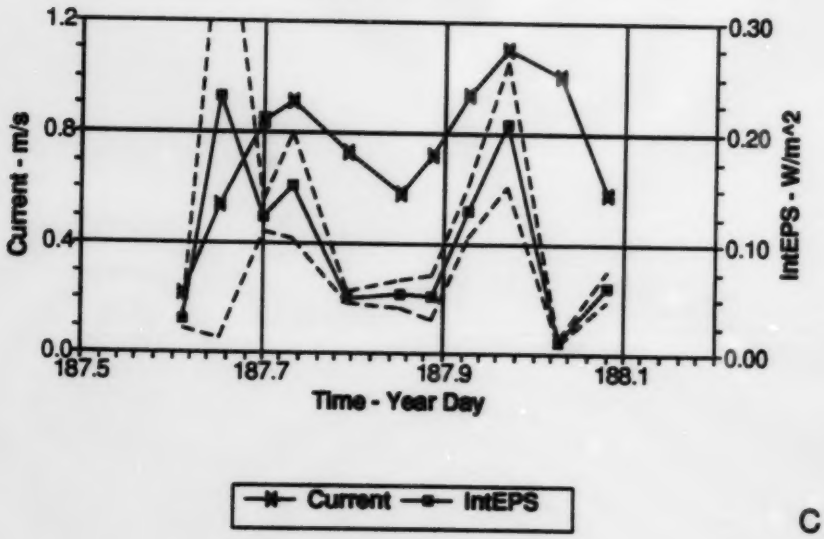
B. The magnitude and the northward component of the vertically averaged composite RCM and Ametek DCP current at half hourly intervals for site 2 coincident with EPSONDE anchor station 2B23.

C. The magnitude of the vertically averaged composite current interpolated to the mean EPSONDE station time and the integrated dissipation, IntEPS, for each EPSONDE station during anchor station 2B23. Error limits are indicated for IntEPS.




Georges Bank '88
SITE 2B23
AvgRate - m/s
VNorth - m/s
1.2
0.8
0.4
0.0
-0.4
-1.2
187.5
187.7
187.9
188.1
Time - Year Day
AvgRate
VNorth

B

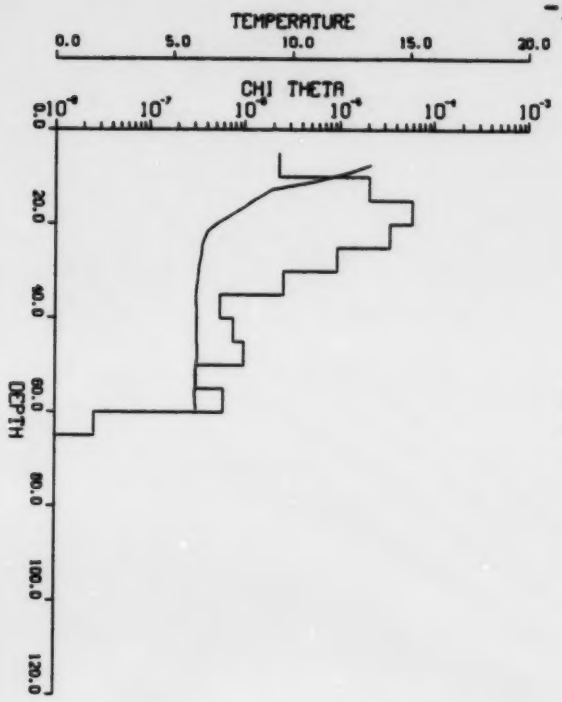

Microstructure Anchor Station
SITE 2B23
Current - m/s
IntEPS - W/m^2
1.2
0.8
0.4
0.0
0.30
0.20
0.10
0.00
187.5
187.7
187.9
188.1
Time - Year Day
Current
IntEPS

C

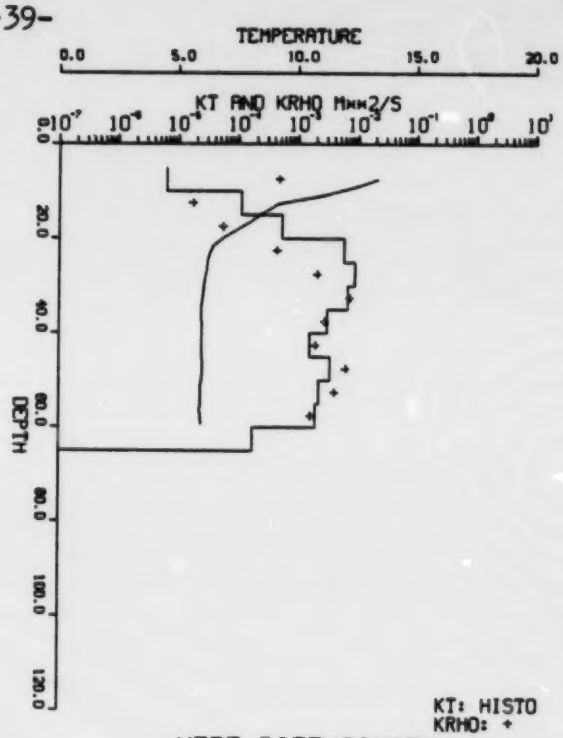
FIGURE 7: Profiles of microstructure quantities for stations 42 to 52 for anchor station 2B23.
- Each page contains a profile of a microstructure quantity averaged over 5 m vertical bins overlaid on a profile of temperature.
- The upper left panel is Chi-Theta, the dissipation of temperature variance.
- The upper right panel contains profiles of vertical diffusivity KT (for temperature) and KRHO for density.
- The lower left panel contains a profile of dissipation, EPSILON.
- The lower right panel shows the profile for Cox number.

The stations are shown in the following order:

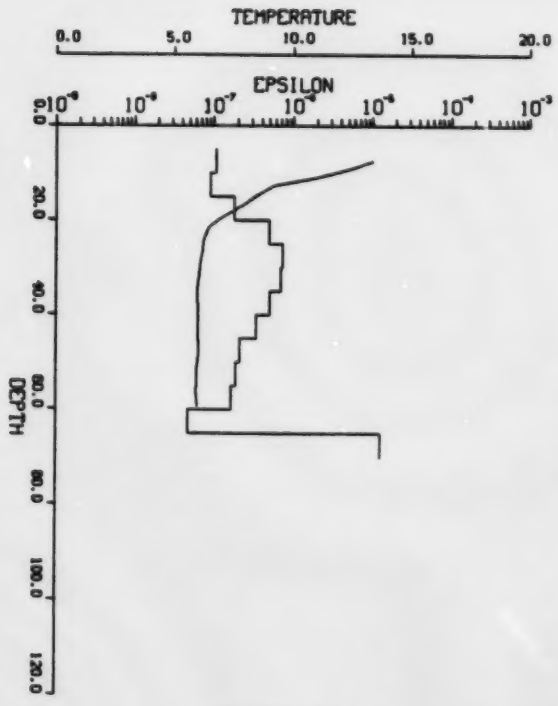
A. Station 42
B. Station 43
C. Station 44
D. Station 45
E. Station 46
F. Station 47
G. Station 48
H. Station 49
I. Station 50
J. Station 51
K. Station 52



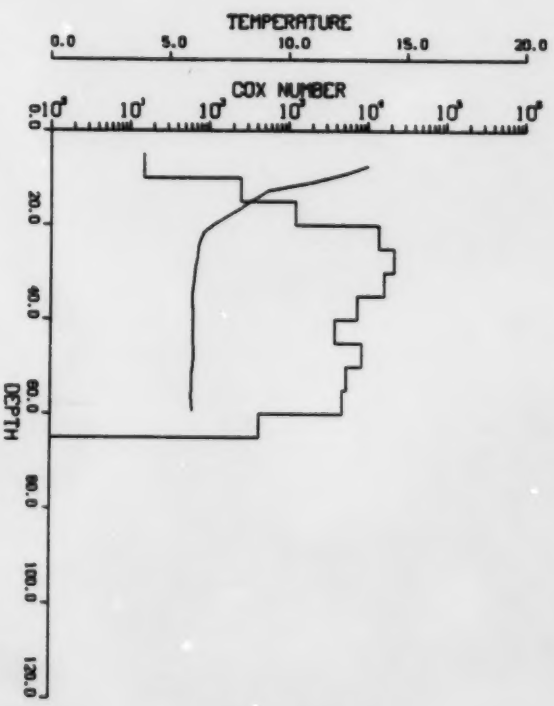

88023 - 042 CHI-THETA




VERT DIFFUSIVITY

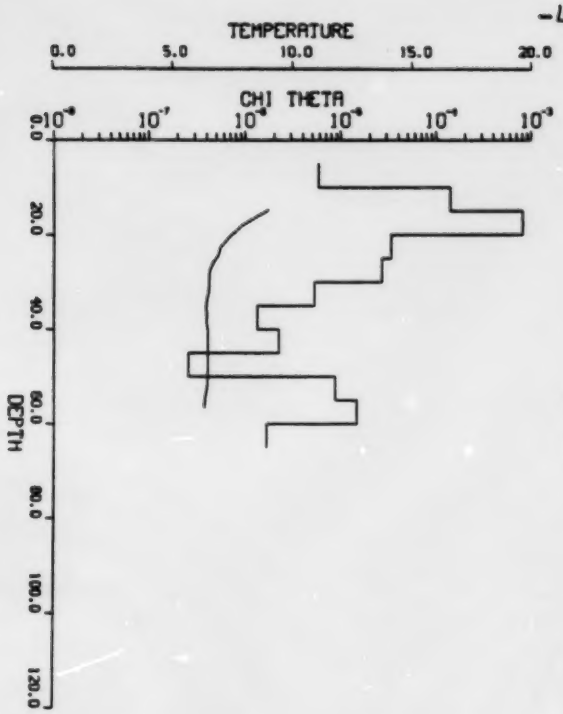



DISSIPATION

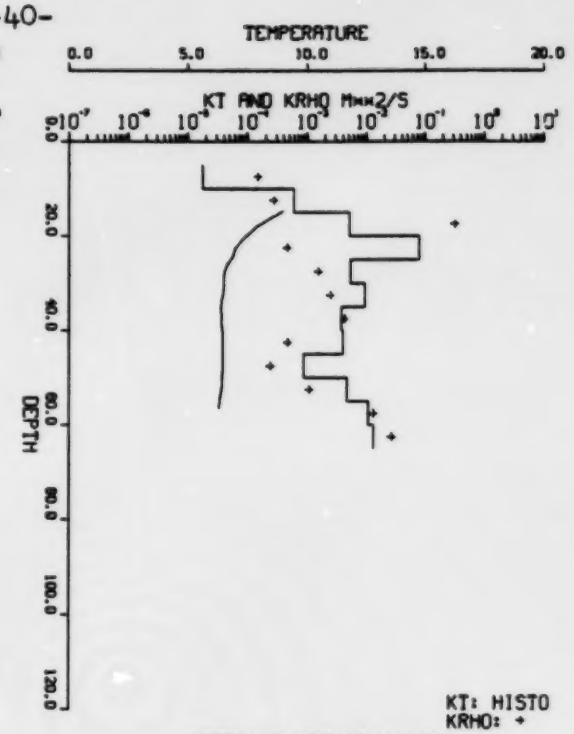



COX NUMBER

A




88023 - 043 CHI-THETA

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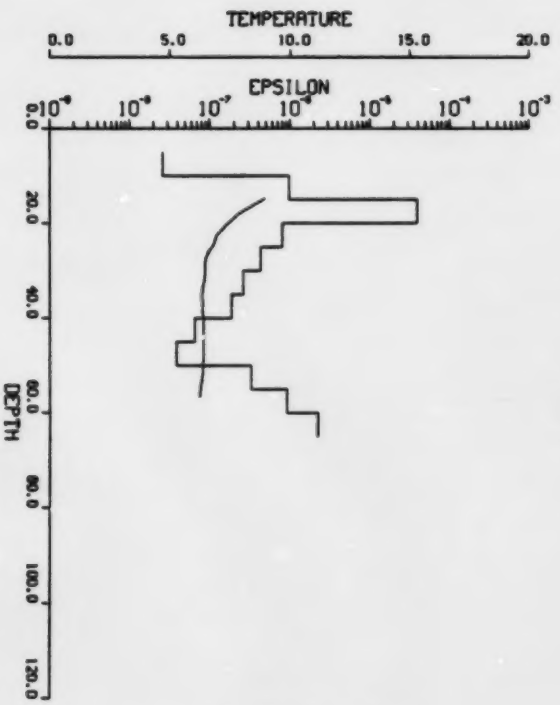


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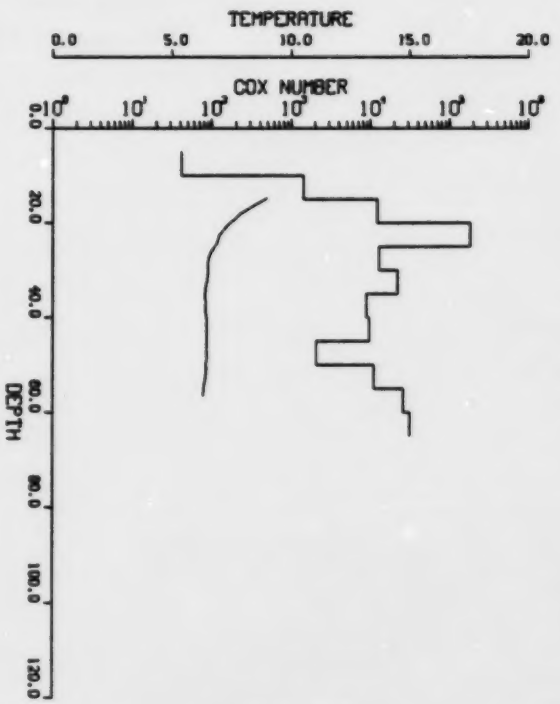
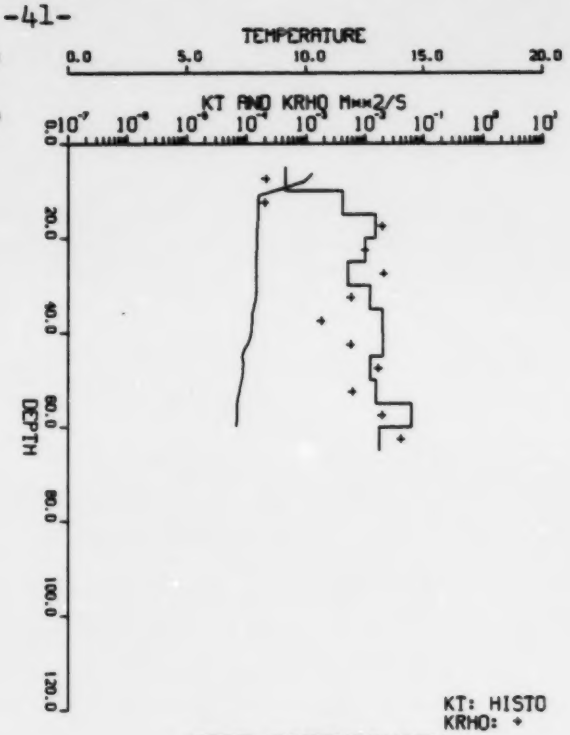


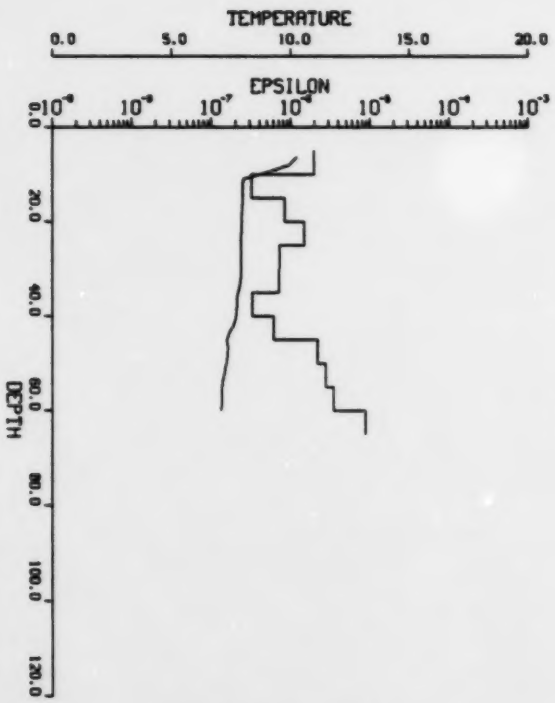

COX NUMBER

B

88023 - 044 CHI-THETA




VERT DIFFUSIVITY

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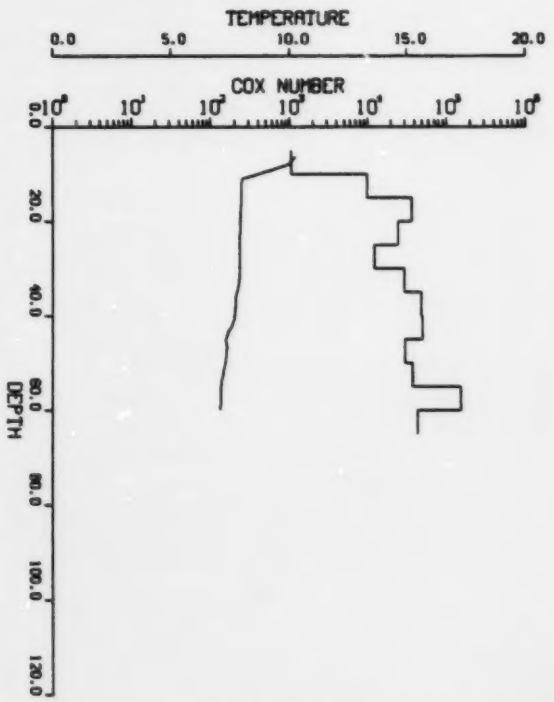
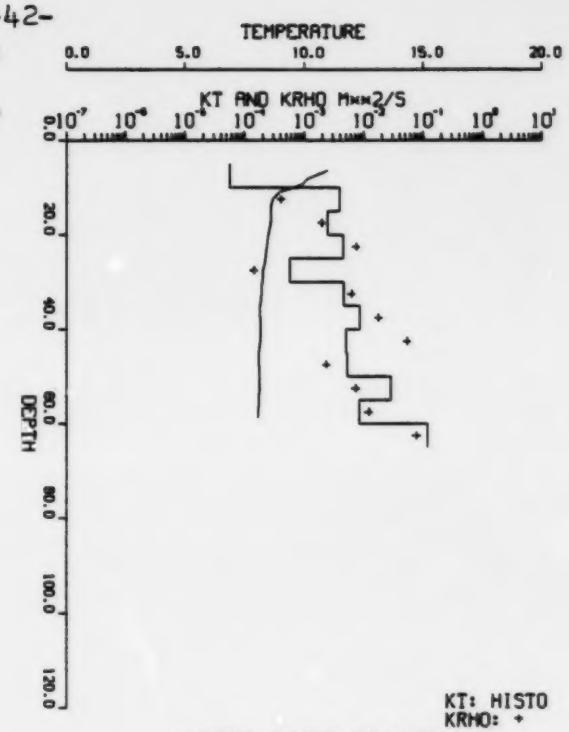



COX NUMBER

C

88023 - 045 CHI-THETA

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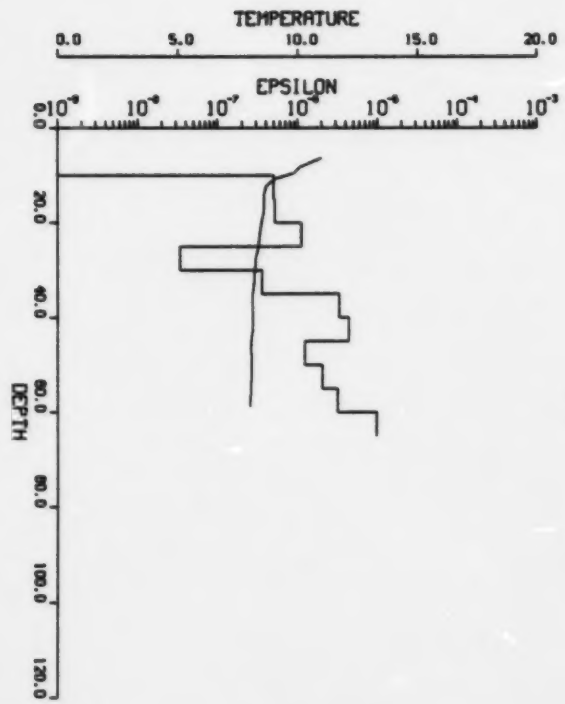


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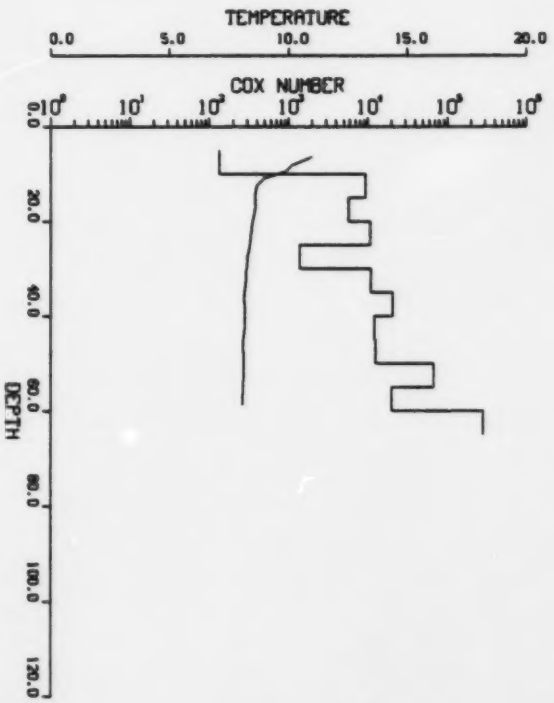


COX NUMBER

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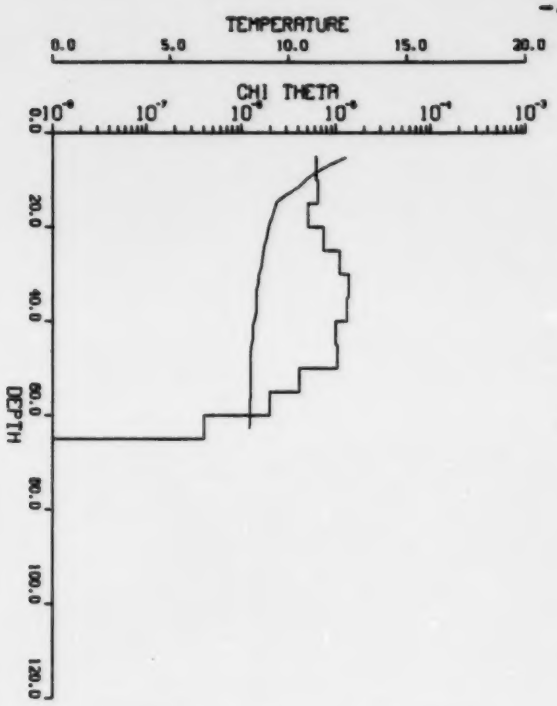
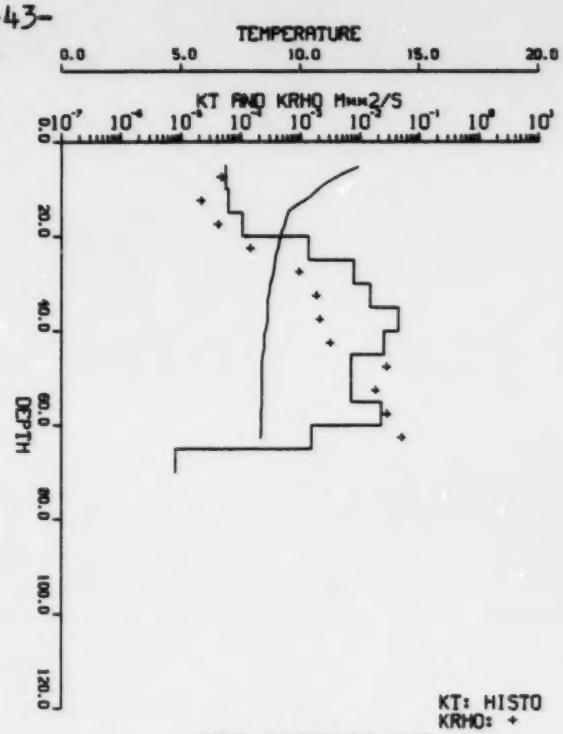



88023 - 046 CHI-THETA




VERT DIFFUSIVITY

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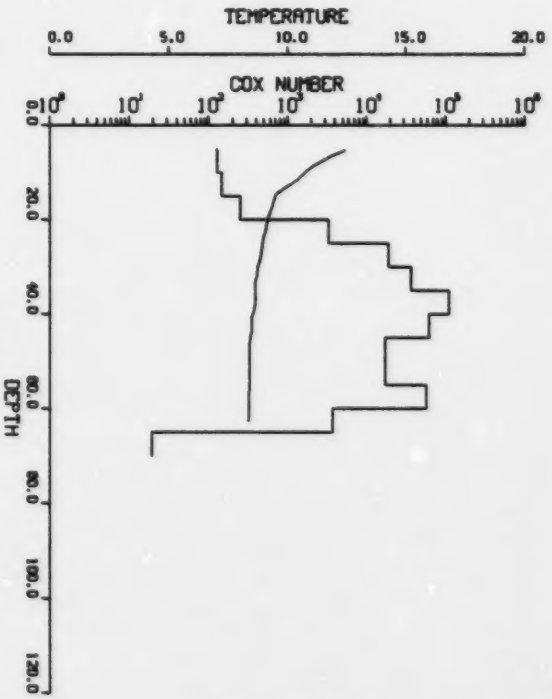


COX NUMBER

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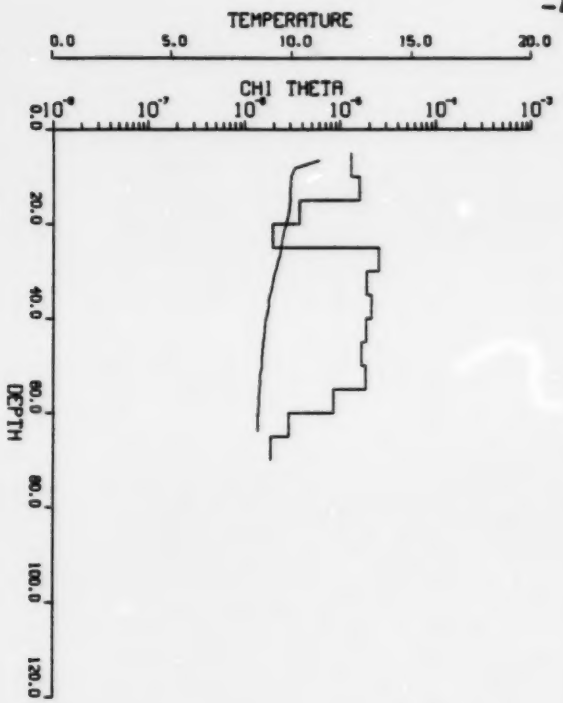
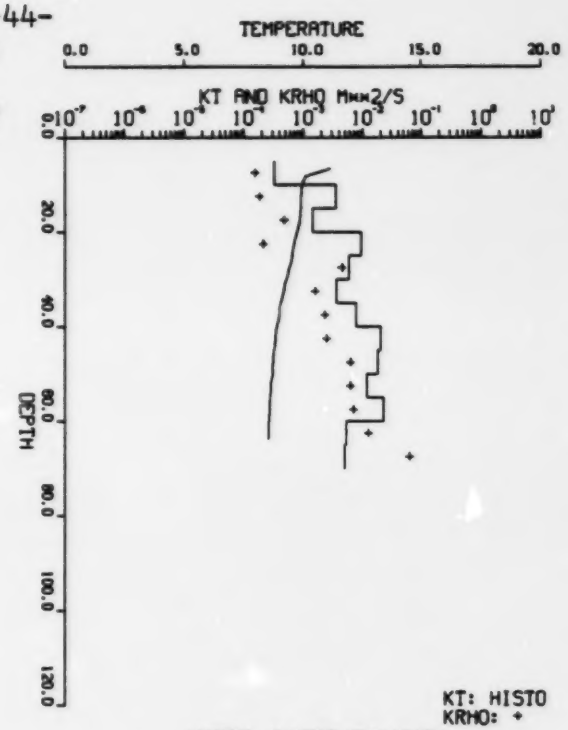



88023 - 047 CHI-THETA

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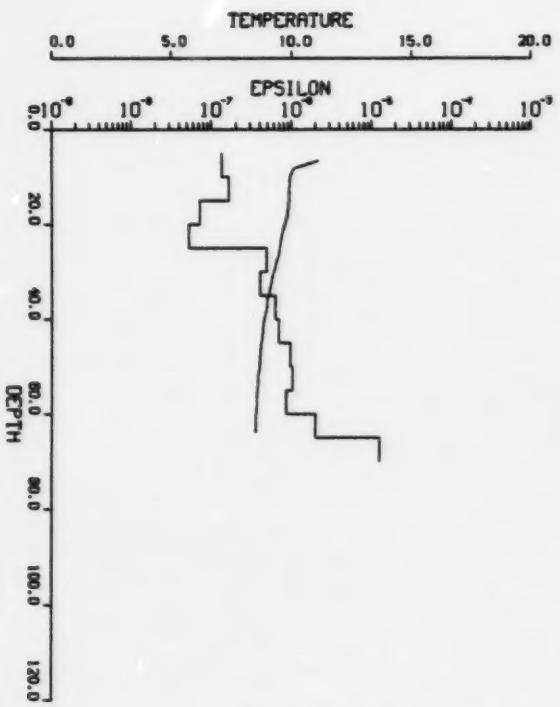


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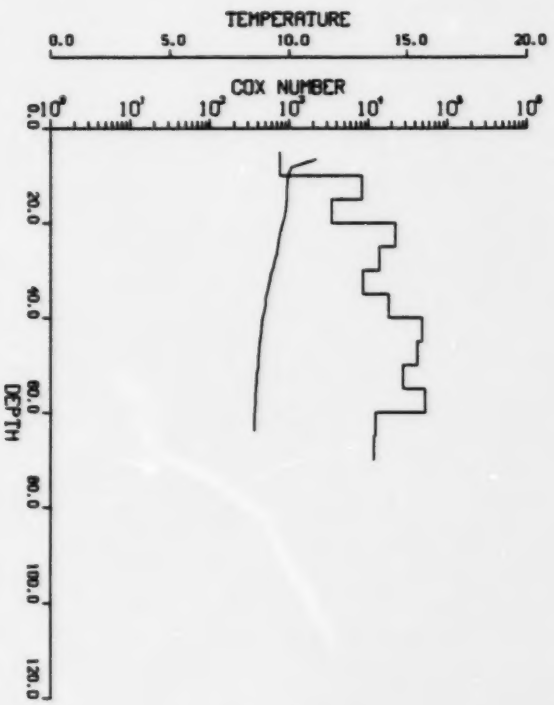


COX NUMBER

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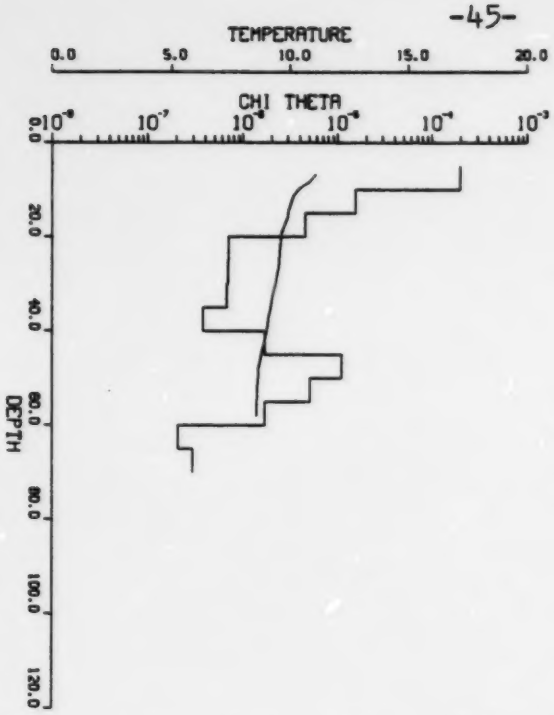


88023 - 048 CHI-THETA

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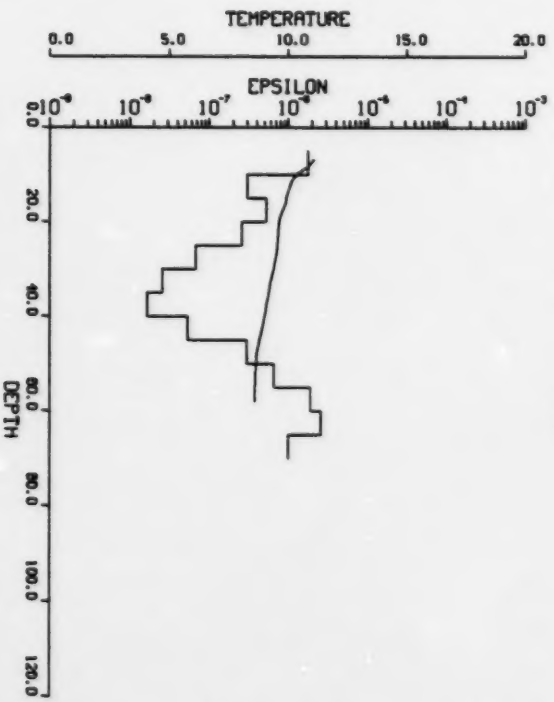


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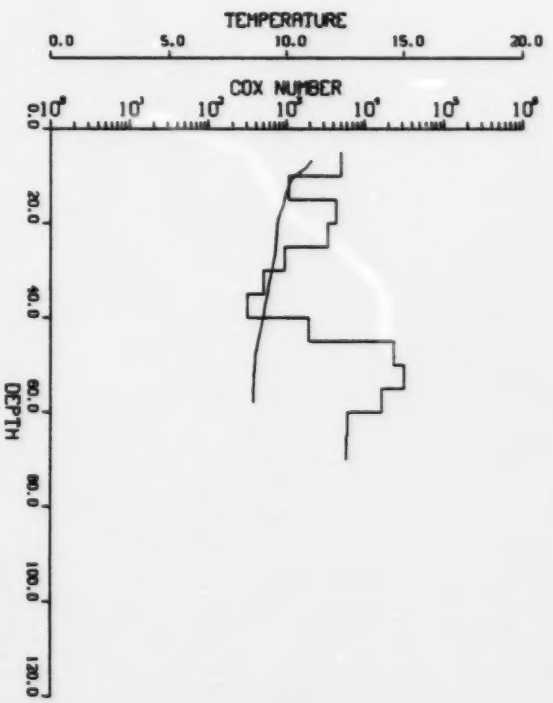
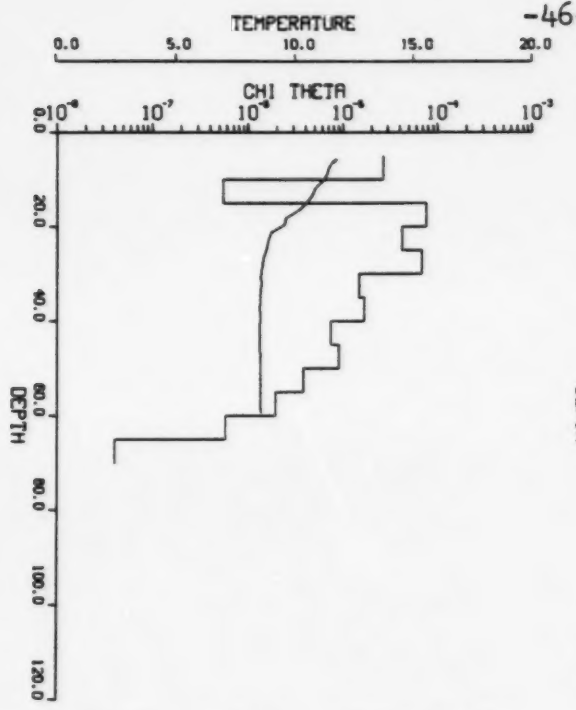



COX NUMBER

G




88023 - 049 CHI-THETA

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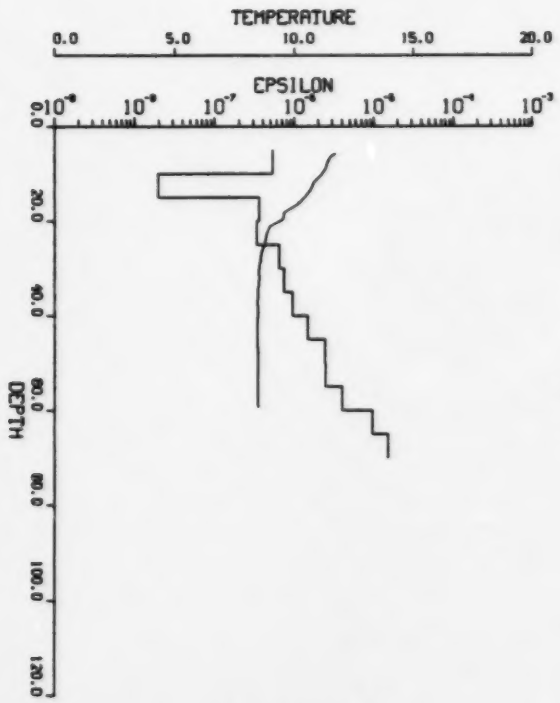
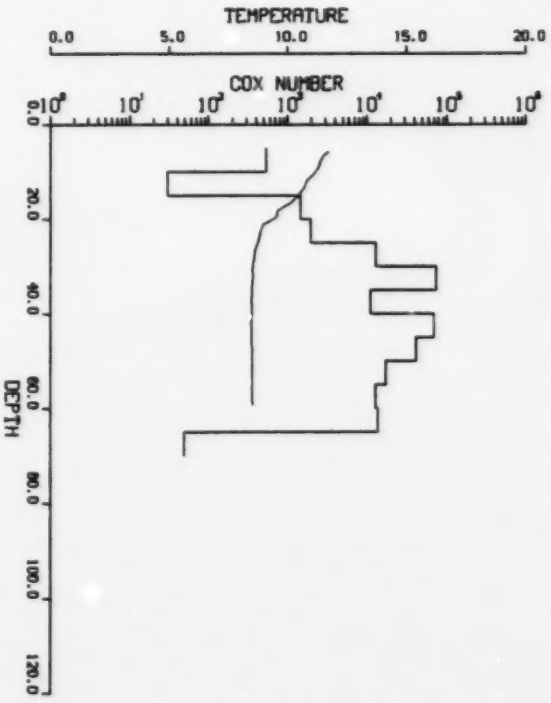



DISSIPATION




COX NUMBER

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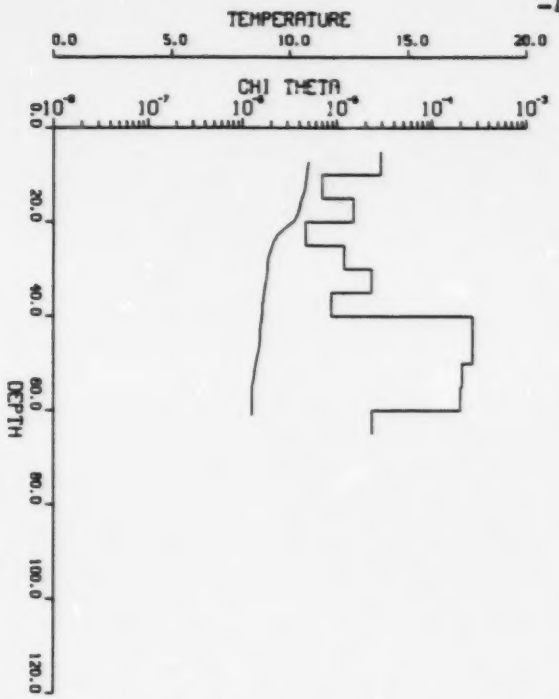
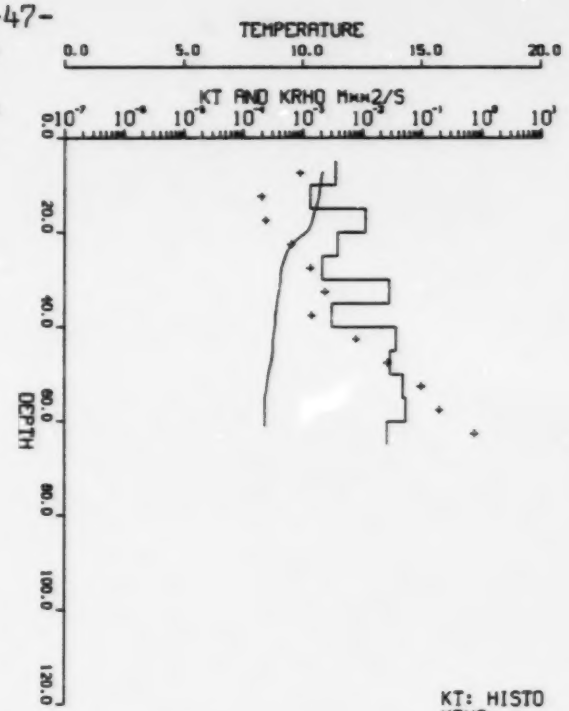



88023 - 050 CHI-THETA

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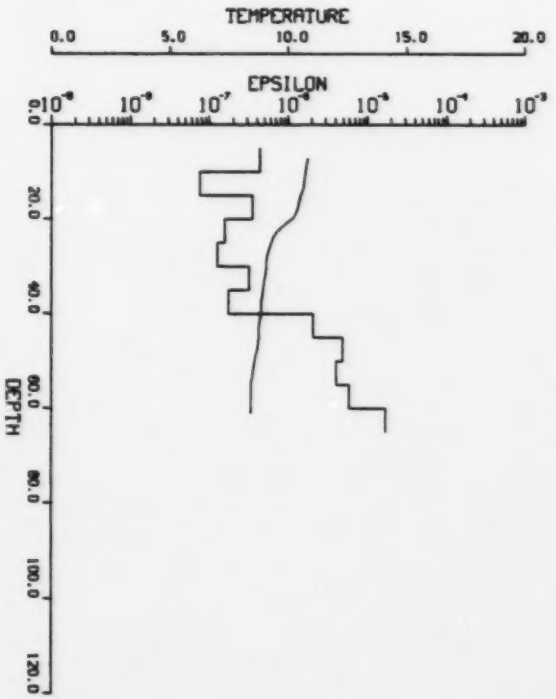


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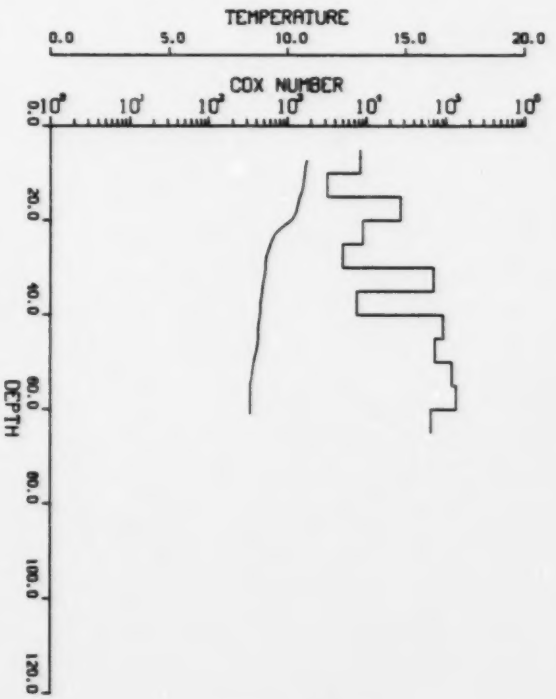


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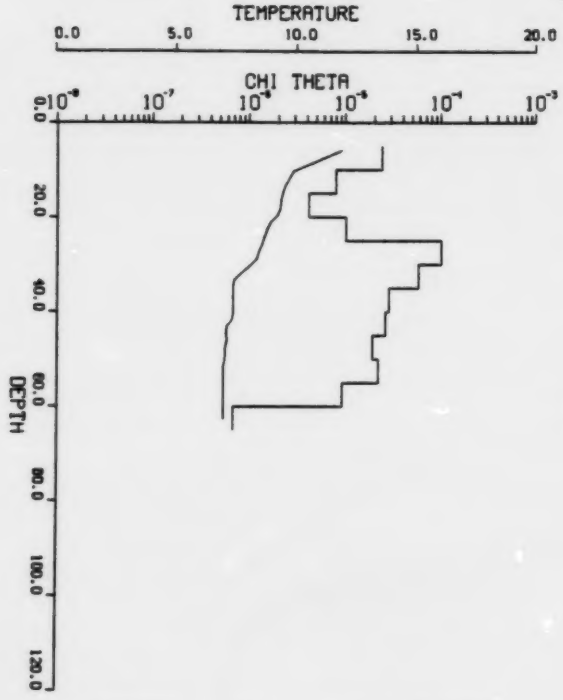
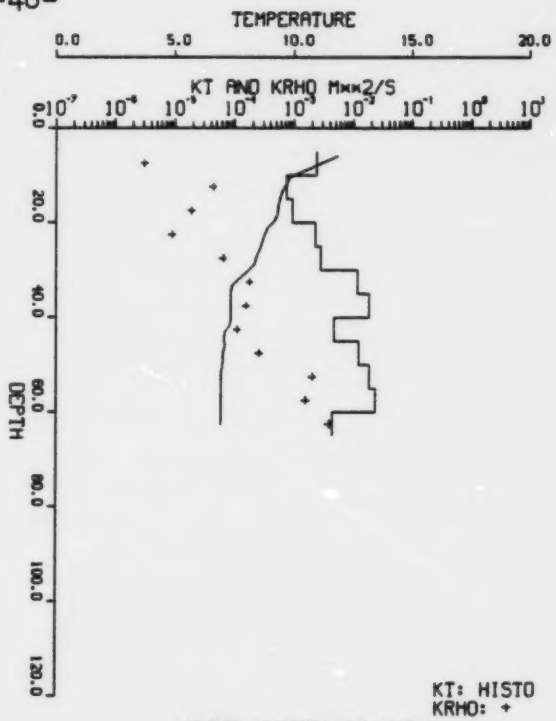



88023 - 051 CHI-THETA

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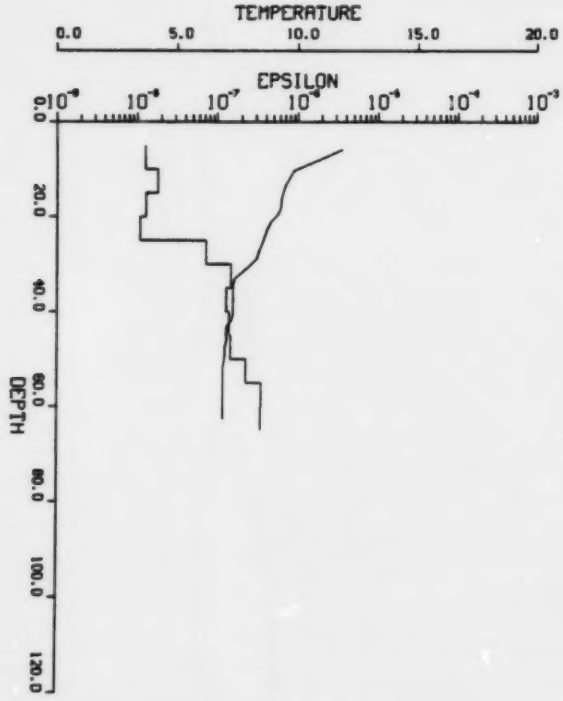


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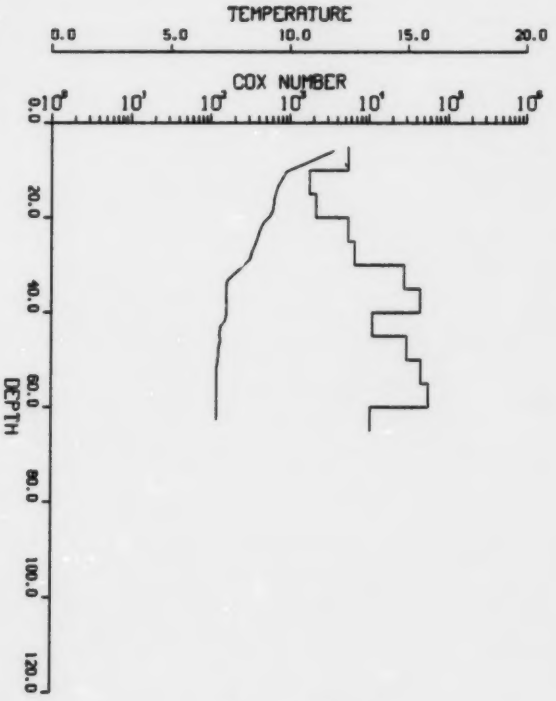
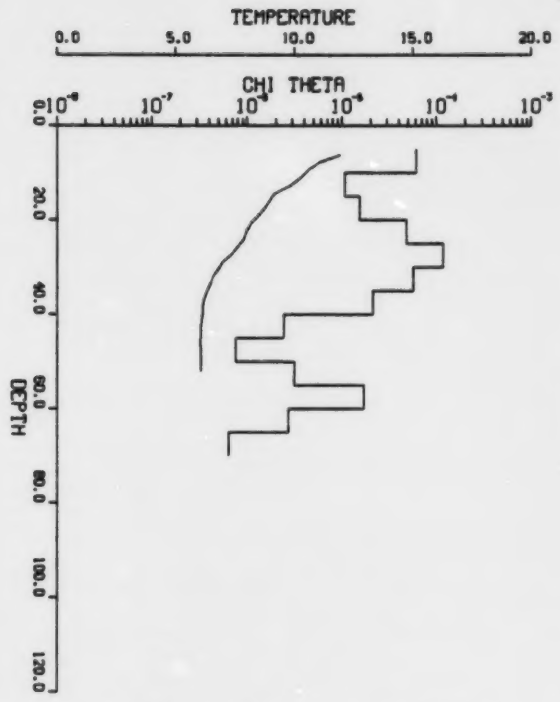
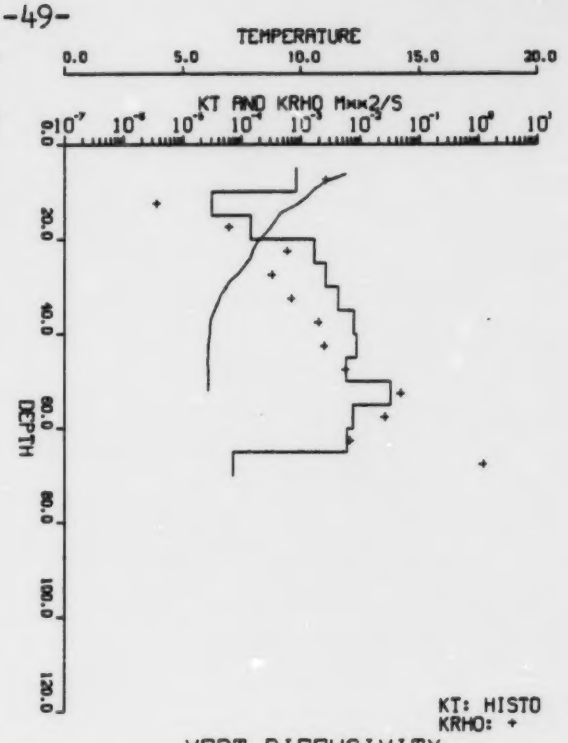


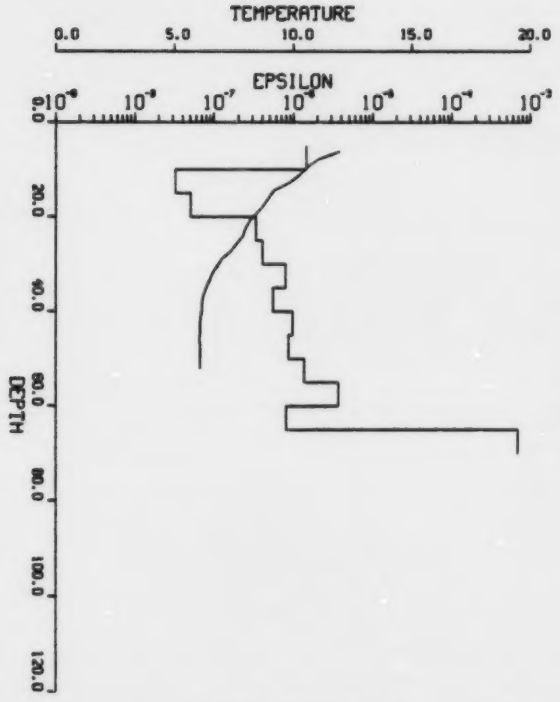

COX NUMBER J



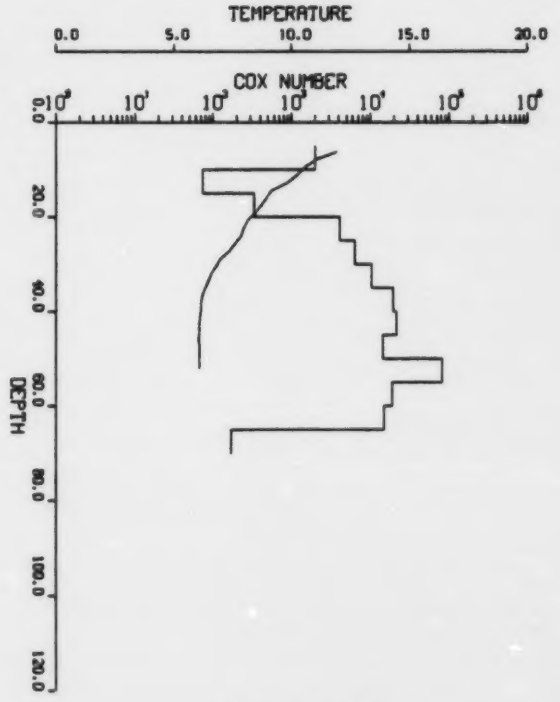

88023 - 052 CHI-THETA




VERT DIFFUSIVITY




DISSIPATION




COX NUMBER K

# SITE 2C23

42°05.13N, 66°46.30W

TABLE 3: COMBINED CURRENT AND DISSIPATION

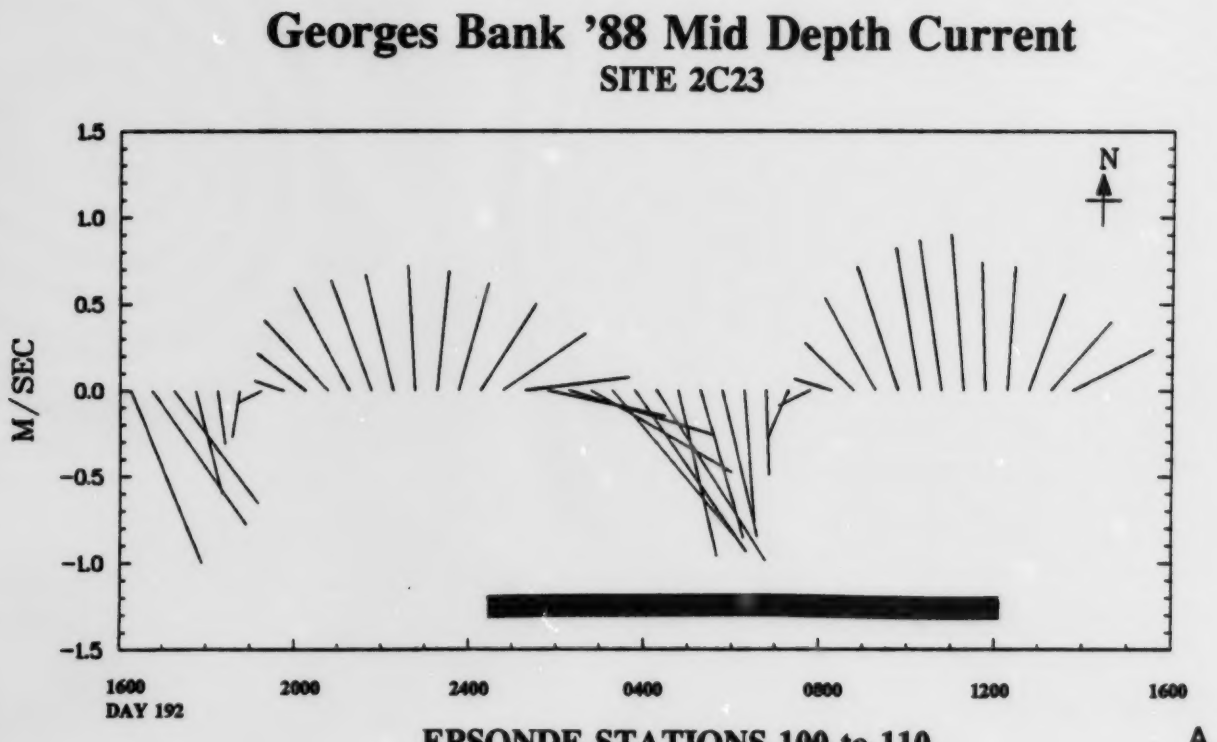
| Station | TimeEPS | Depth | Drops | Current | IntEPS | ErrEPS |
|---|---|---|---|---|---|---|
| E100 | 193.0340 | 66.00 | 8 | 0.470 | 0.0062 | 0.0017 |
| E101 | 193.0778 | 64.70 | 7 | 0.581 | 0.0097 | 0.0039 |
| E102 | 193.1174 | 62.25 | 8 | 0.809 | 0.1278 | 0.0697 |
| E103 | 193.1635 | 62.75 | 8 | 1.017 | 0.1927 | 0.0691 |
| E104 | 193.2063 | 66.00 | 8 | 0.975 | 0.2171 | 0.0560 |
| E105 | 193.2497 | 64.75 | 6 | 0.737 | 0.0898 | 0.0305 |
| E106 | 193.2910 | 63.05 | 8 | 0.389 | 0.0399 | 0.0099 |
| E107 | 193.3788 | 66.00 | 8 | 0.486 | 0.0750 | 0.0142 |
| E108 | 193.4139 | 65.05 | 6 | 0.690 | 0.0507 | 0.0169 |
| E109 | 193.4545 | 66.00 | 8 | 0.794 | 0.0842 | 0.0180 |
| E110 | 193.4955 | 66.00 | 8 | 0.811 | 0.0800 | 0.0061 |

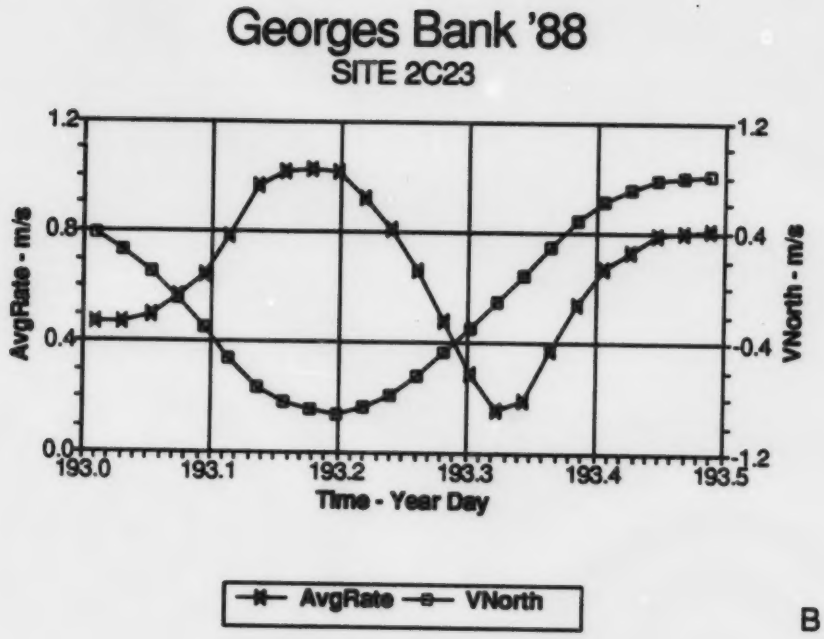
FIGURE 8:

A. Current vector plot for the RCM at 35m depth at site 2 overlapping the EPSONDE anchor station 2C during cruise 88023 (2C23). This anchor station includes EPSONDE stations 100 to 110.

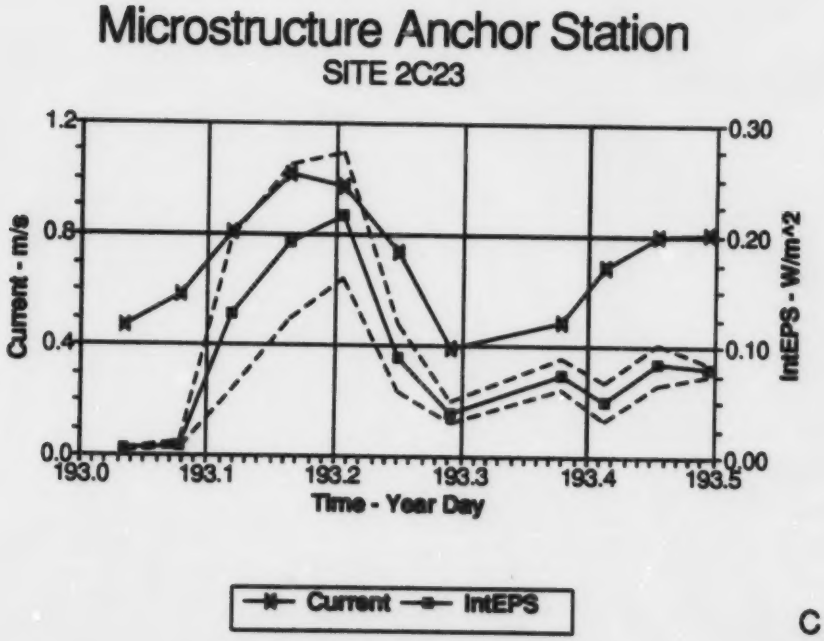
B. The magnitude and the northward component of the vertically averaged composite RCM and Ametek DCP current at half hourly intervals for site 2 coincident with EPSONDE anchor station 2C23.

C. The magnitude of the vertically averaged composite current interpolated to the mean EPSONDE station time and the integrated dissipation, IntEPS, for each EPSONDE station during anchor station 2C23. Error limits are indicated for IntEPS.




Georges Bank '88
SITE 2C23
AvgRate - m/s
VNorth - m/s
1.2
0.8
0.4
0.0
-0.4
-1.2
193.0
193.1
193.2
193.3
193.4
193.5
Time - Year Day
AvgRate
VNorth

B

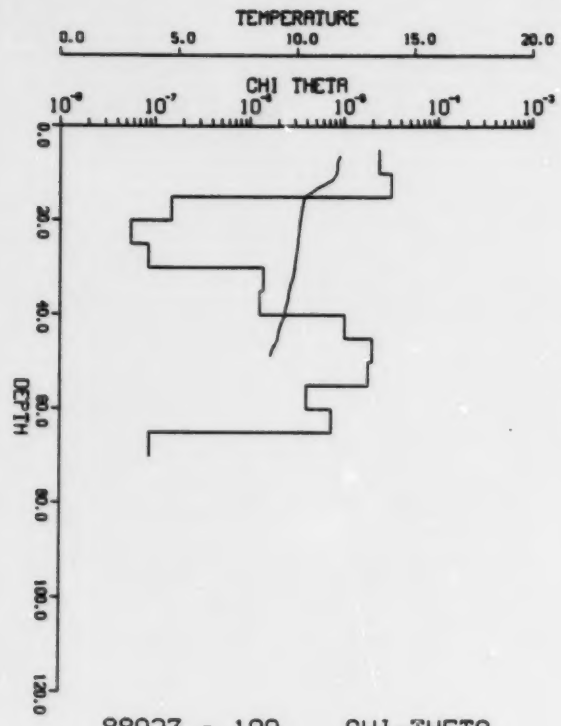

Microstructure Anchor Station
SITE 2C23
Current - m/s
IntEPS - W/m^2
1.2
0.8
0.4
0.0
0.30
0.20
0.10
0.00
193.0
193.1
193.2
193.3
193.4
193.5
Time - Year Day
Current
IntEPS

C

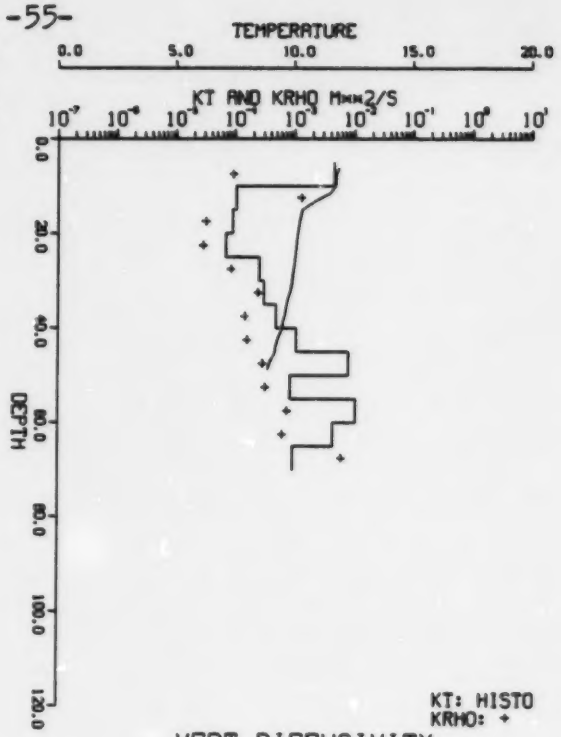
FIGURE 9: Profiles of microstructure quantities for stations 100 to 110 for anchor station 2C23.
- Each page contains a profile of a microstructure quantity averaged over 5 m vertical bins overlaid on a profile of temperature.
- The upper left panel is Chi-Theta, the dissipation of temperature variance.
- The upper right panel contains profiles of vertical diffusivity KT (for temperature) and KRHO for density.
- The lower left panel contains a profile of dissipation, EPSILON.
- The lower right panel shows the profile for Cox number.

The stations are shown in the following order:

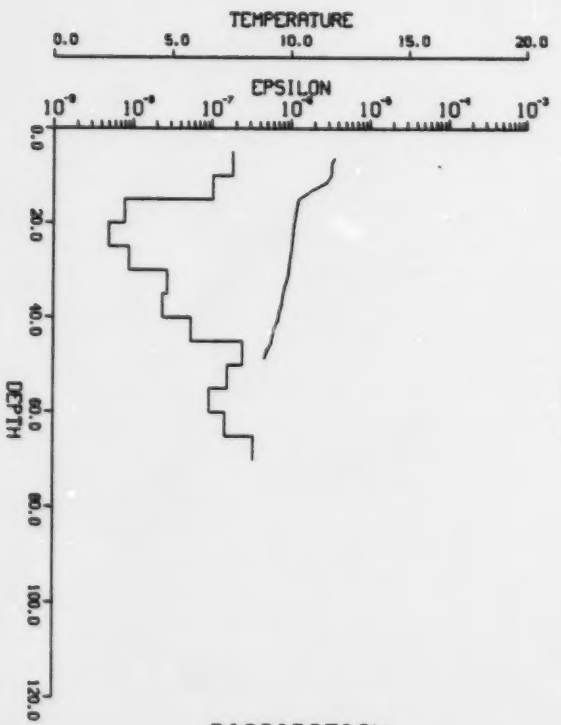
A. Station 100
B. Station 101
C. Station 102
D. Station 103
E. Station 104
F. Station 105
G. Station 106
H. Station 107
I. Station 108
J. Station 109
K. Station 110



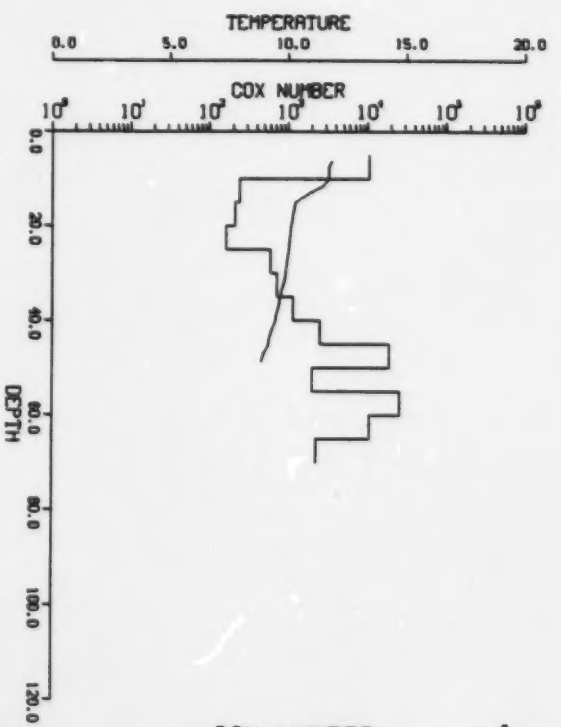

88023 - 100 CHI-THETA



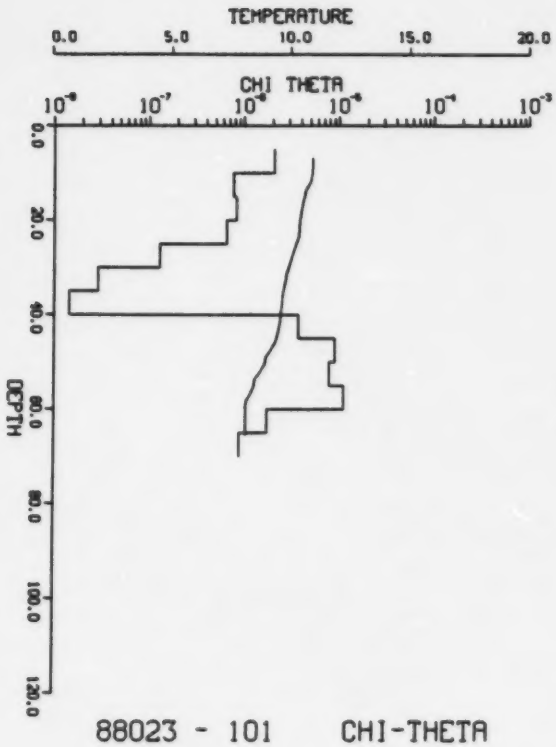

VERT DIFFUSIVITY



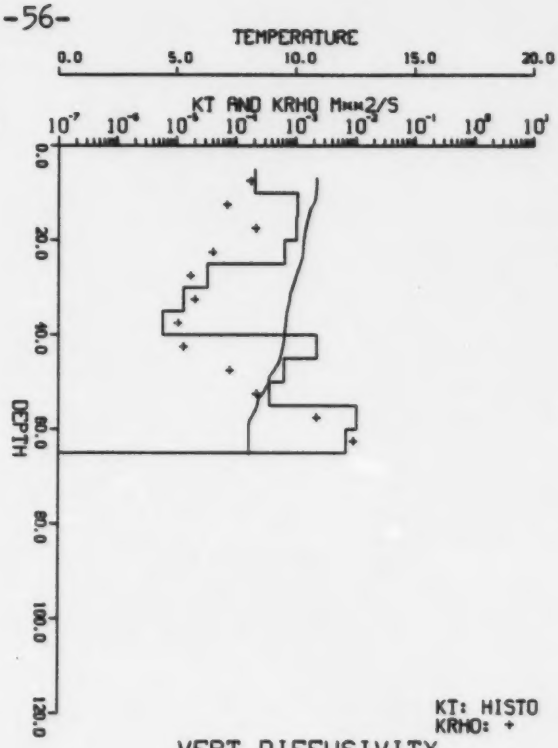

DISSIPATION



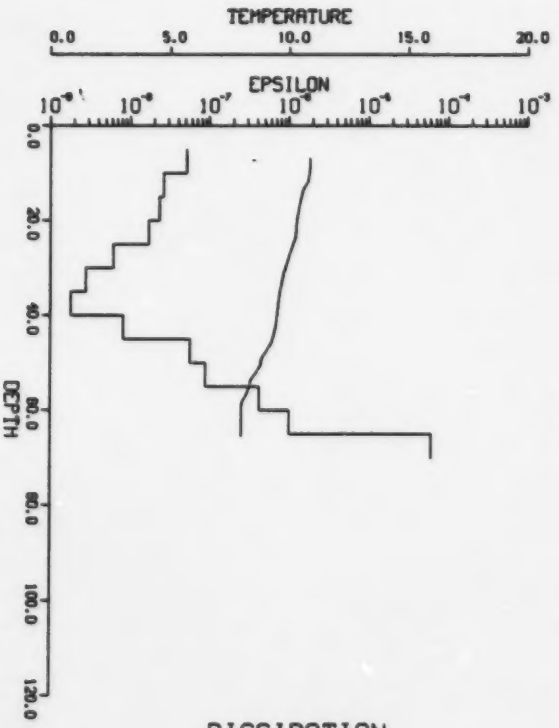

COX NUMBER A




88023 - 101 CHI-THETA




VERT DIFFUSIVITY

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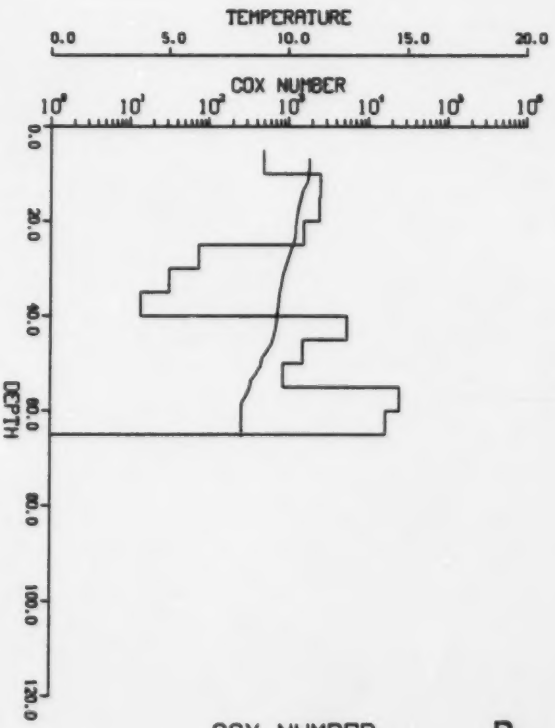
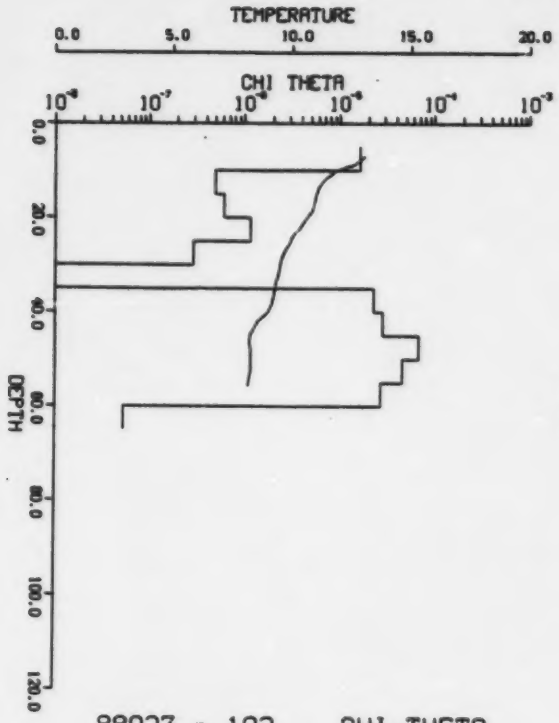
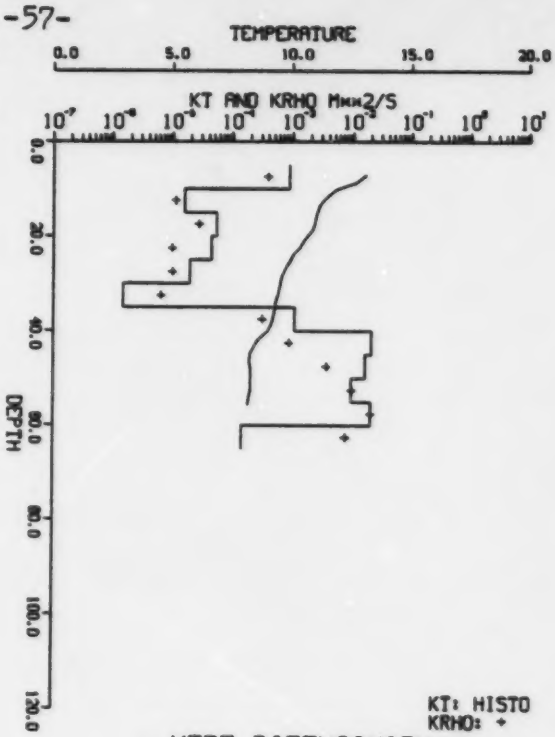


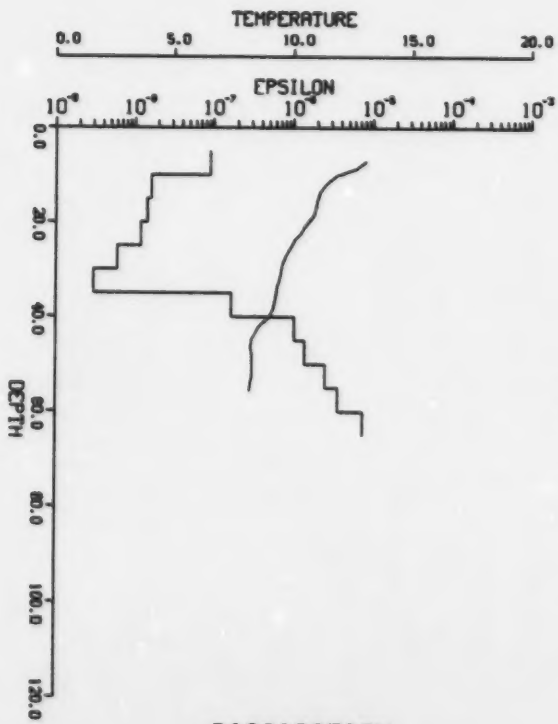

COX NUMBER B




88023 - 102 CHI-THETA




VERT DIFFUSIVITY

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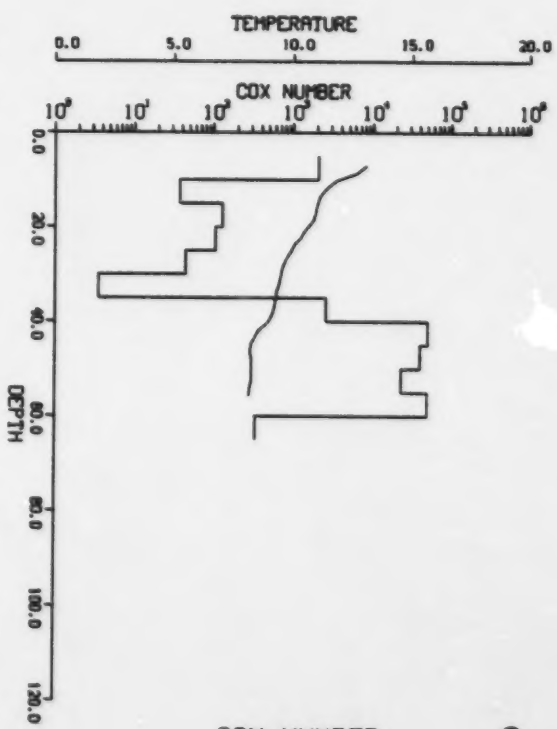
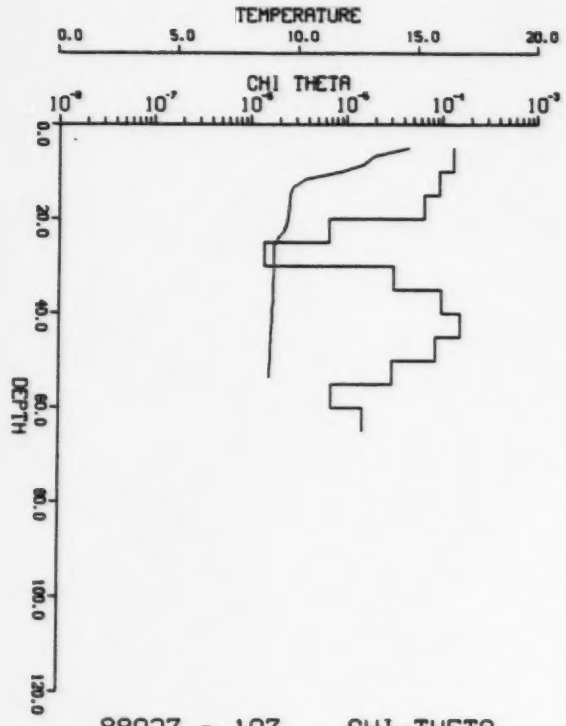
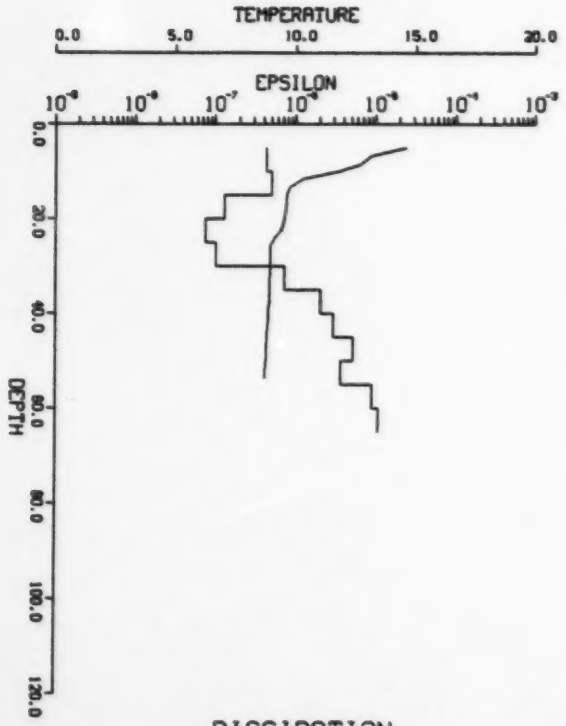



COX NUMBER C

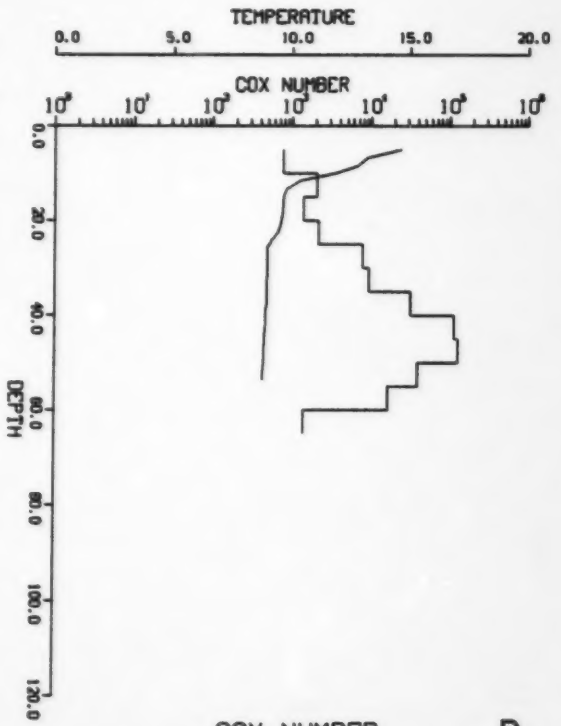



88023 - 103 CHI-THETA

VERT DIFFUSIVITY

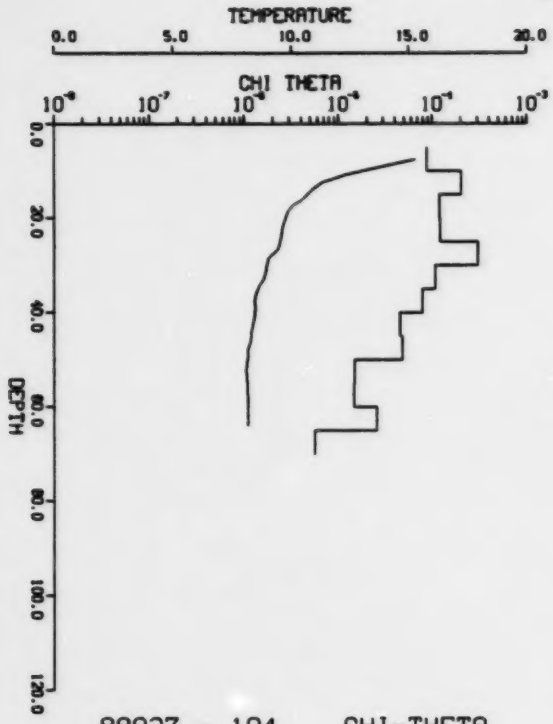



DISSIPATION

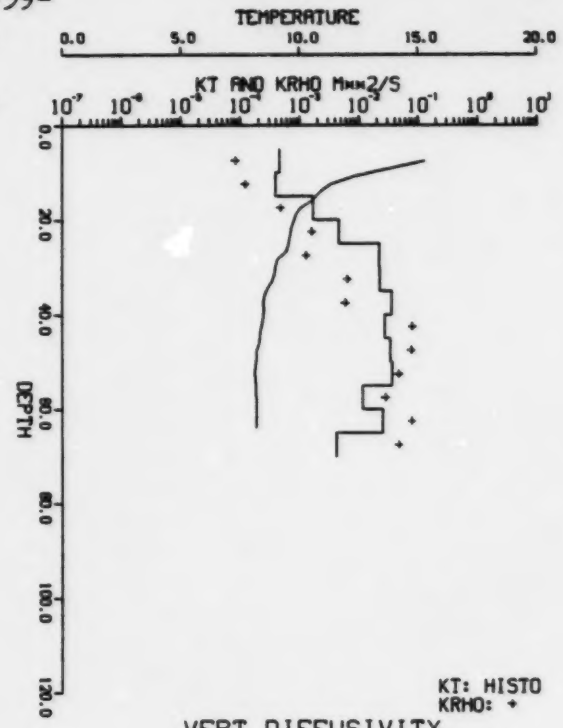



COX NUMBER

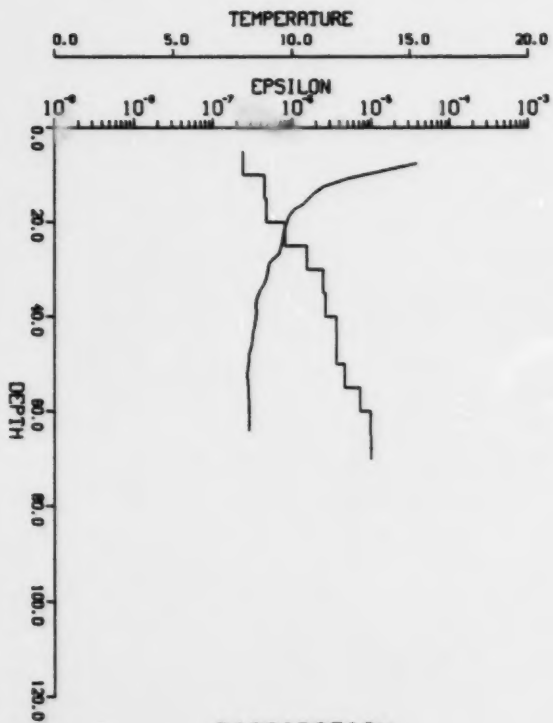
D




88023 - 104 CHI-THETA




VERT DIFFUSIVITY

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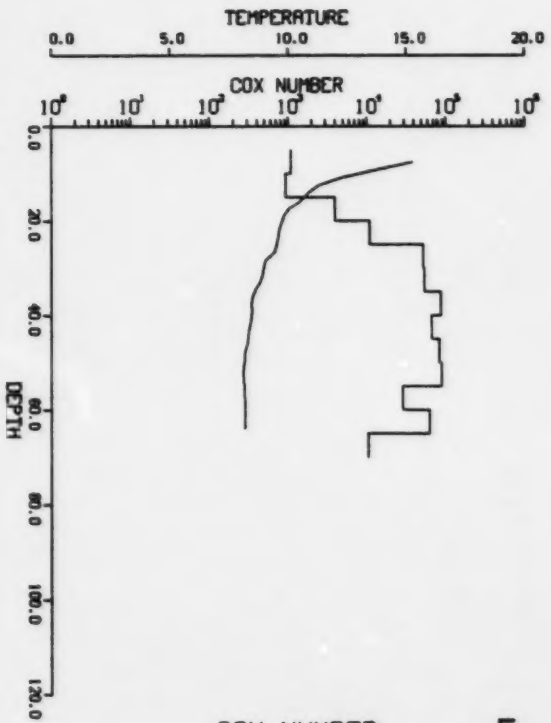
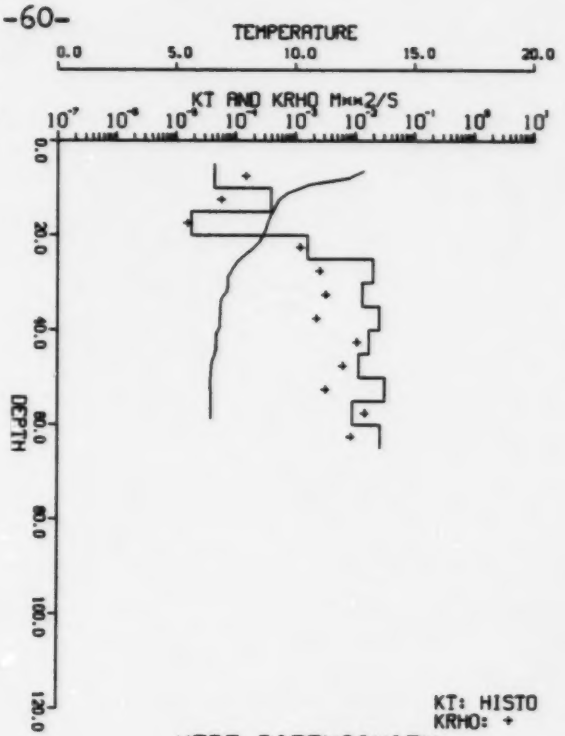



COX NUMBER E

88023 - 105 CHI-THETA

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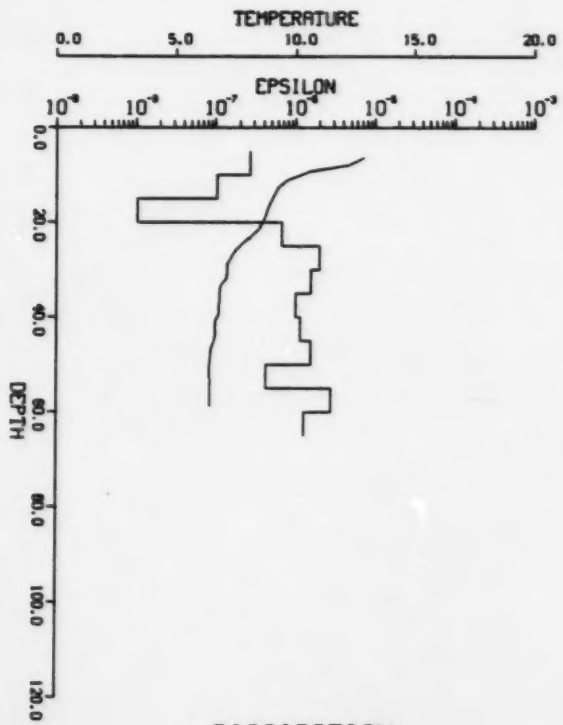


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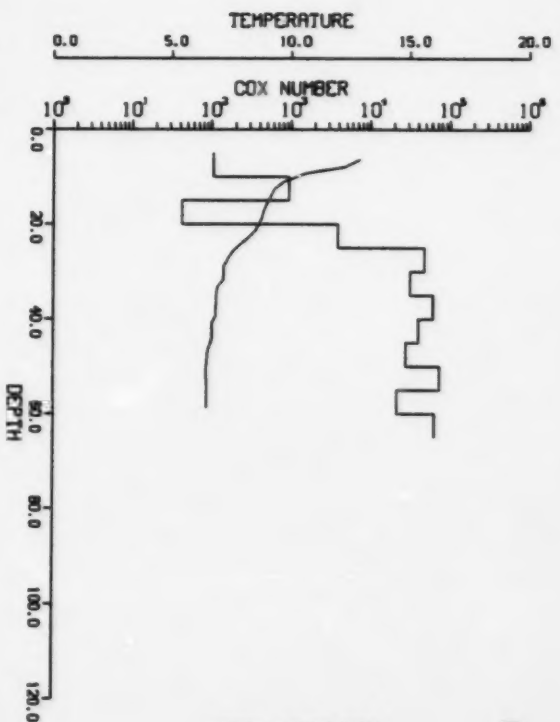


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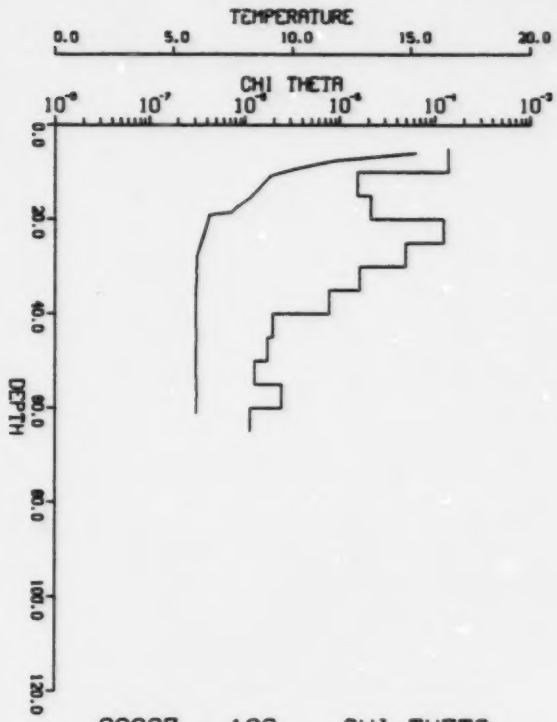
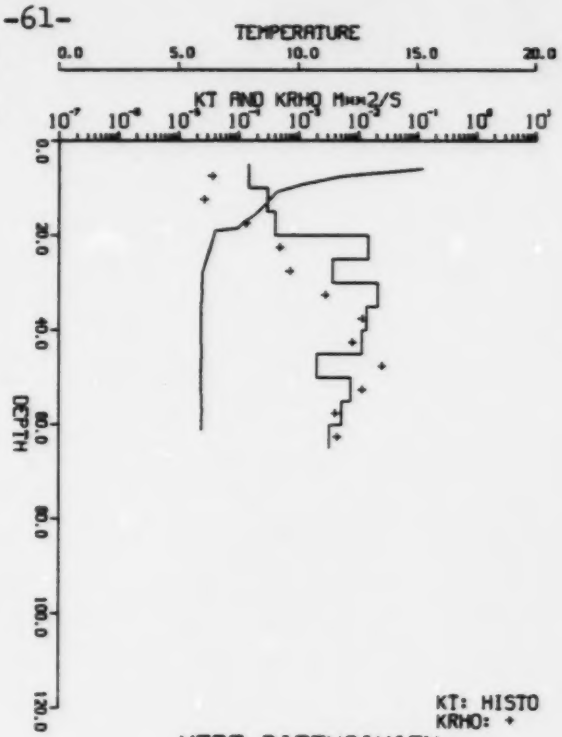
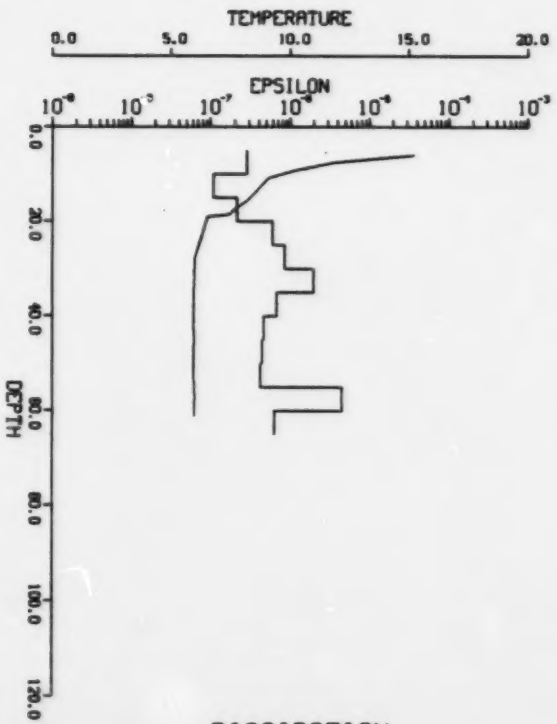



88023 - 106 CHI-THETA




VERT DIFFUSIVITY

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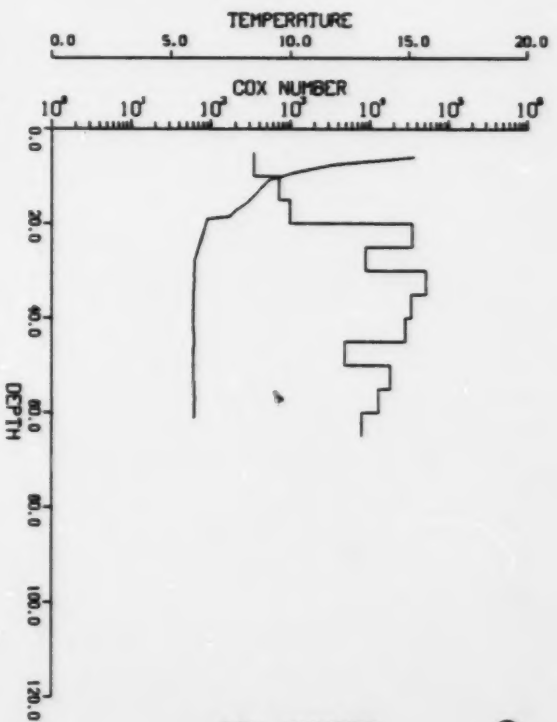


COX NUMBER

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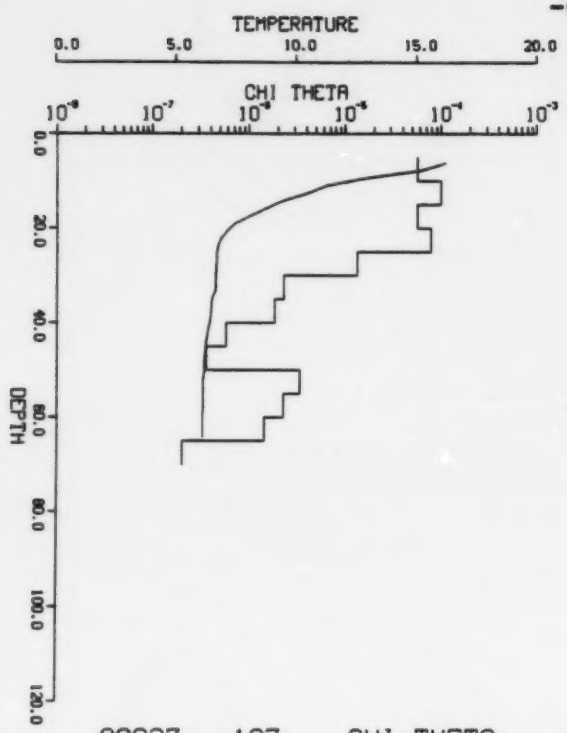
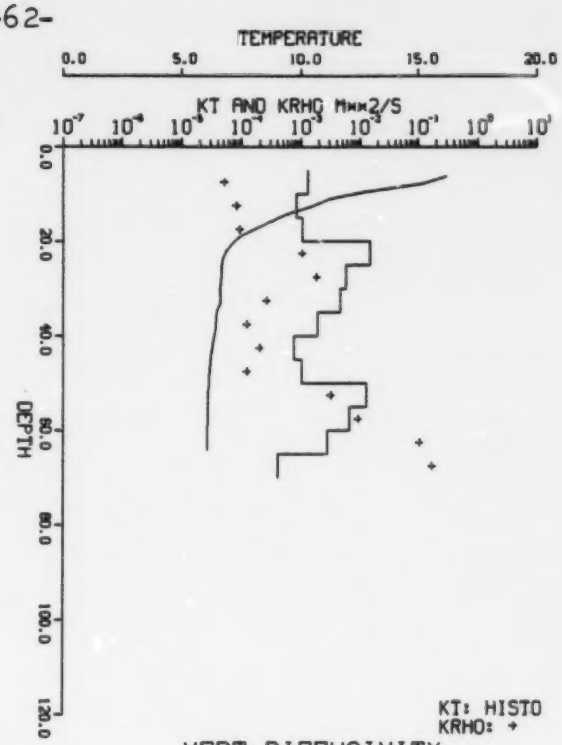
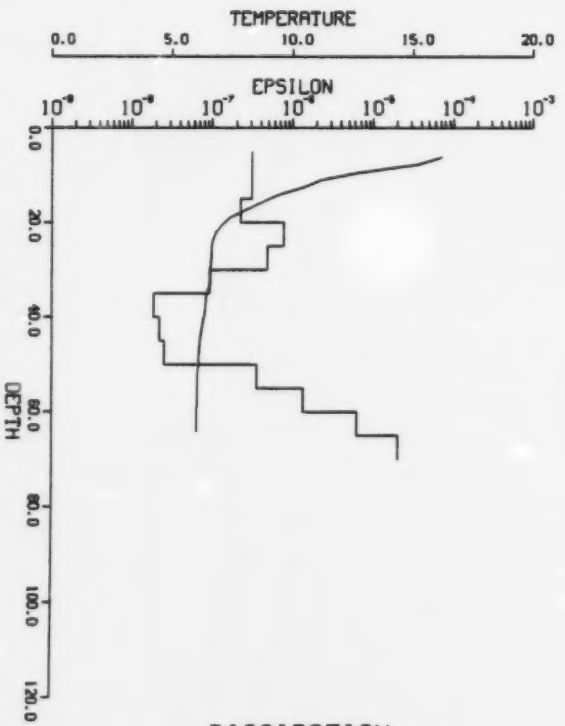


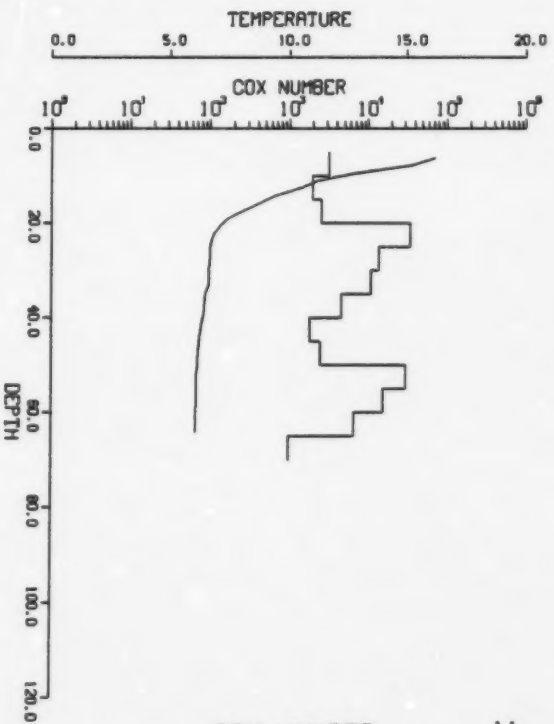

88023 - 107 CHI-THETA




VERT DIFFUSIVITY

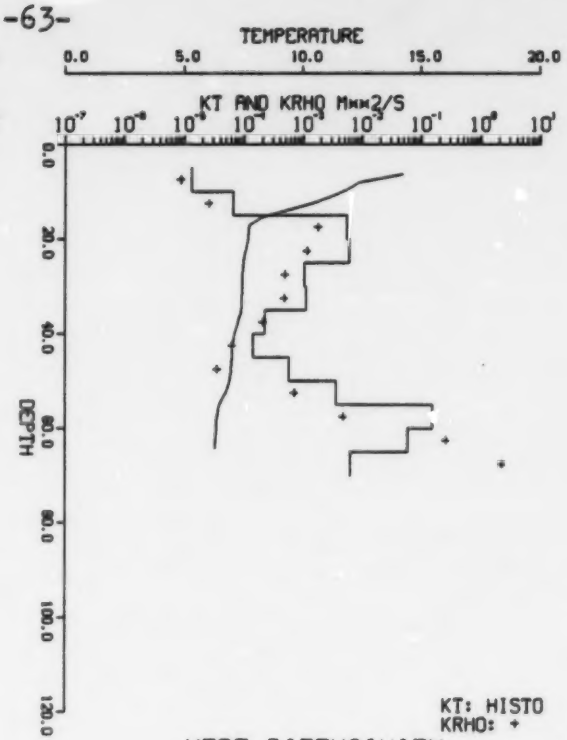



DISSIPATION




COX NUMBER H

88023 - 108 CHI-THETA

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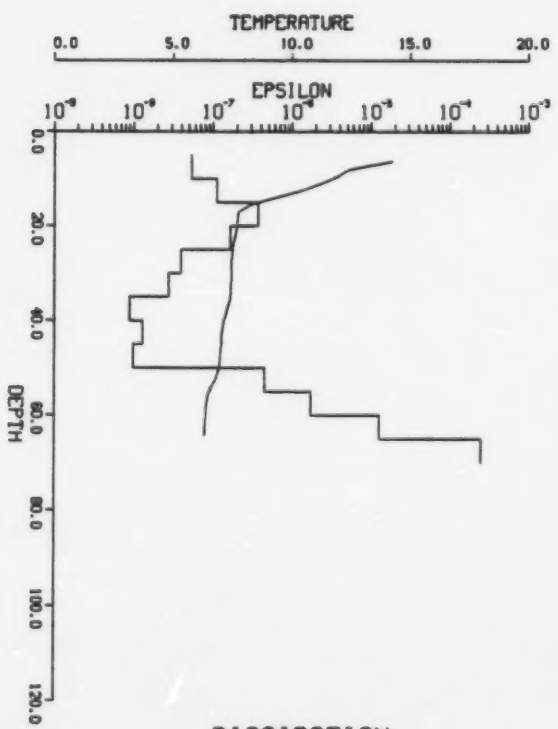


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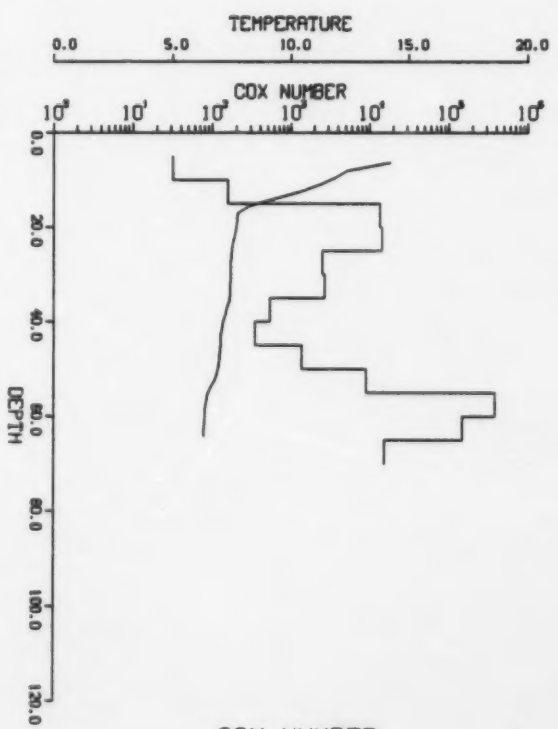


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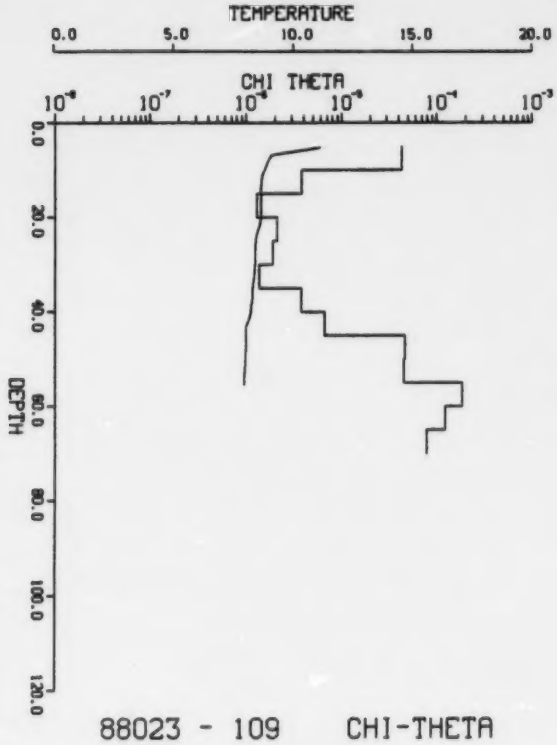
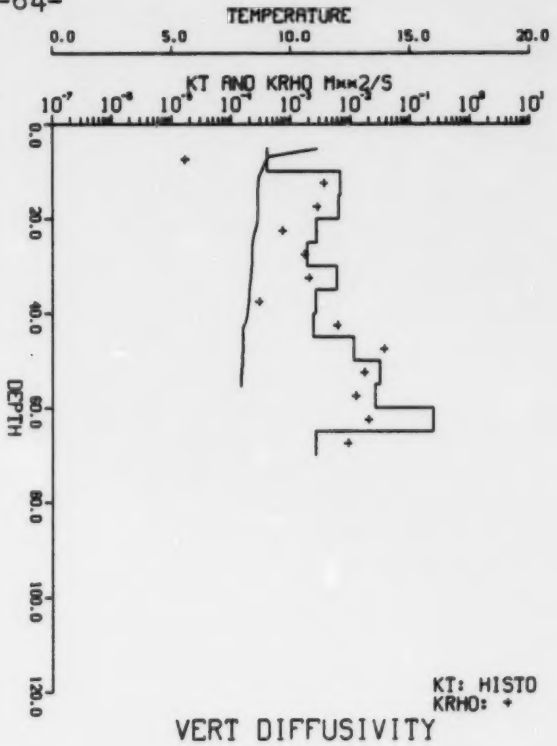



88023 - 109 CHI-THETA

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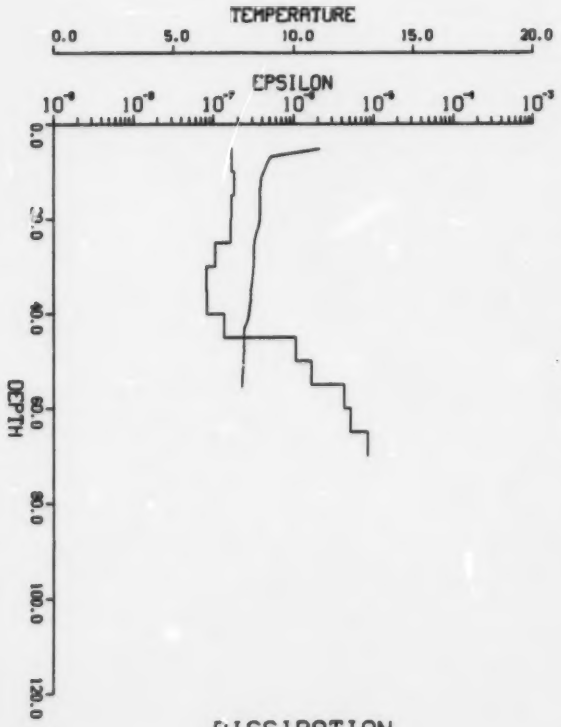


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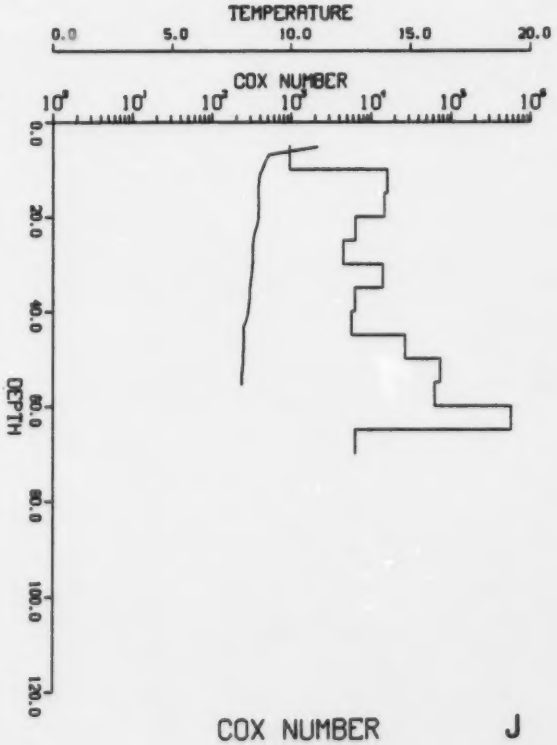
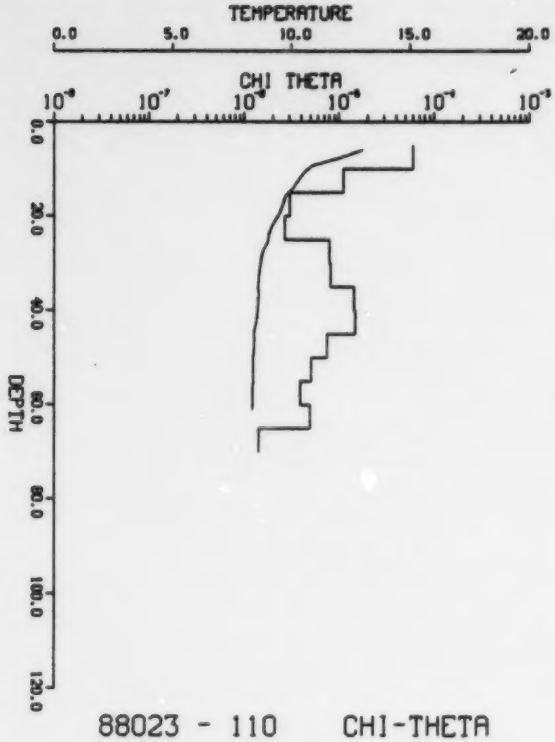
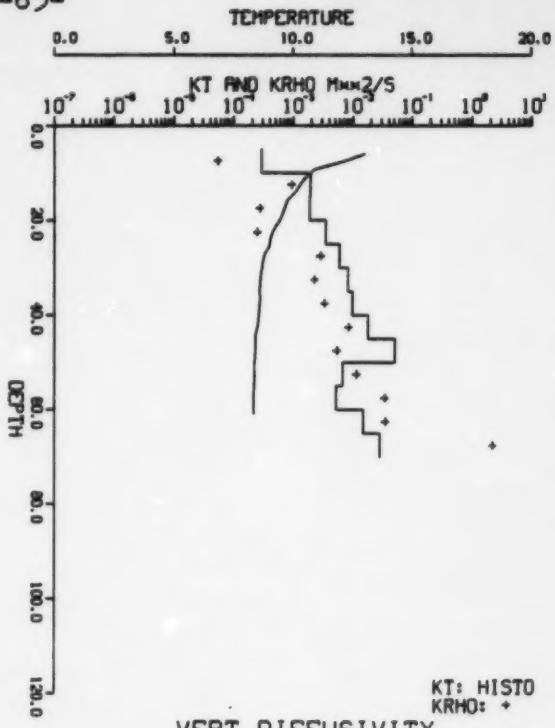



COX NUMBER J




88023 - 110 CHI-THETA

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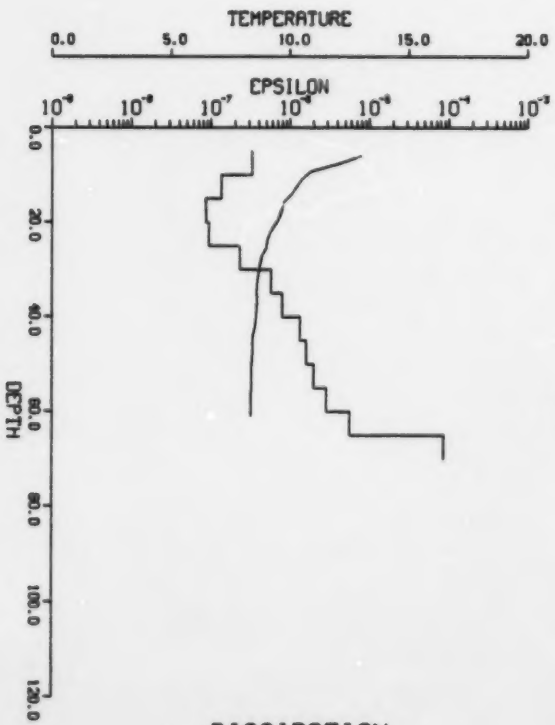


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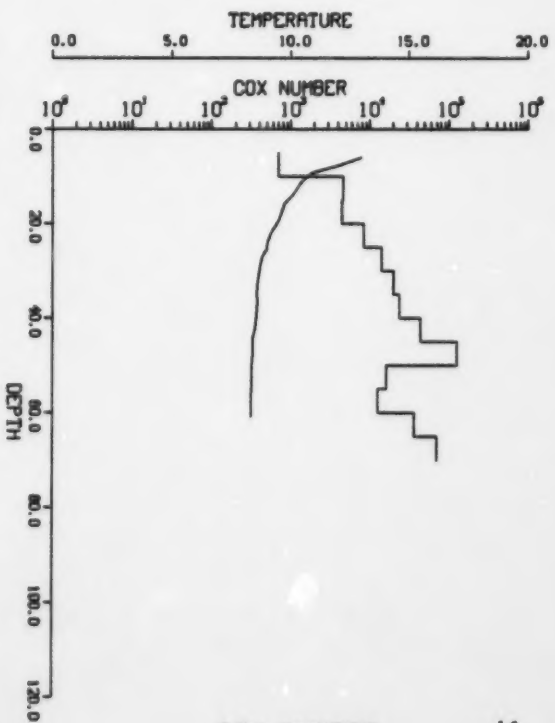



COX NUMBER K

# SITE 3A23

41°59.77N, 66°46.64W

TABLE 4: COMBINED CURRENT AND DISSIPATION

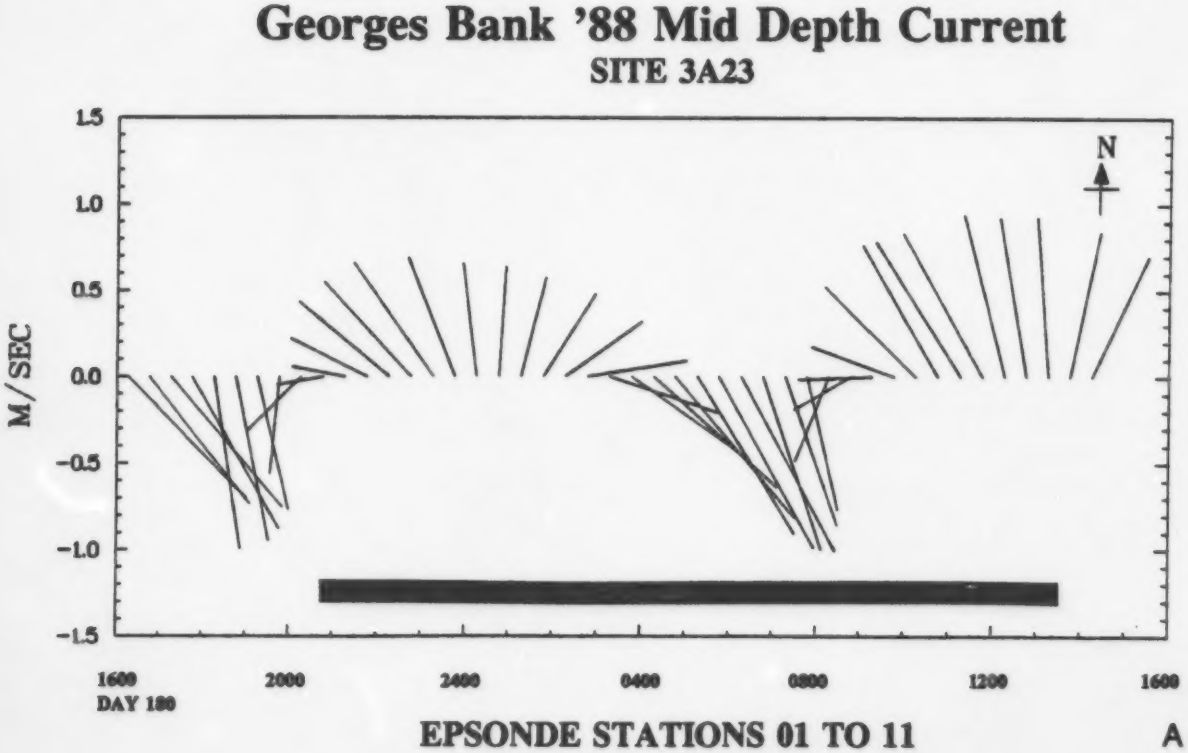
| Station | TimeEPS | Depth | Drops | Current | IntEPS | ErrEPS |
|---|---|---|---|---|---|---|
| E01 | 180.8705 | 63.25 | 5 | 0.365 | 0.0387 | 0.0072 |
| E02 | 180.9500 | 64.00 | 10 | 0.659 | 0.1252 | 0.0212 |
| E03 | 181.0184 | 58.90 | 6 | 0.585 | 0.0652 | 0.0299 |
| E04 | 181.0997 | 64.00 | 8 | 0.448 | 0.0308 | 0.0077 |
| E05 | 181.2024 | 63.00 | 5 | 0.929 | 0.1485 | 0.0301 |
| E06 | 181.2809 | 63.60 | 8 | 0.945 | 0.3175 | 0.0348 |
| E07 | 181.3510 | 63.25 | 8 | 0.466 | 0.0907 | 0.0143 |
| E08 | 181.4066 | 63.20 | 8 | 0.485 | 0.0790 | 0.0153 |
| E09 | 181.4538 | 64.00 | 8 | 0.738 | 0.1545 | 0.0300 |
| E10 | 181.4986 | 63.60 | 2 | 0.952 | 0.1872 | 0.0654 |
| E11 | 181.5632 | 64.00 | 2 | 0.906 | 0.1701 | 0.0086 |

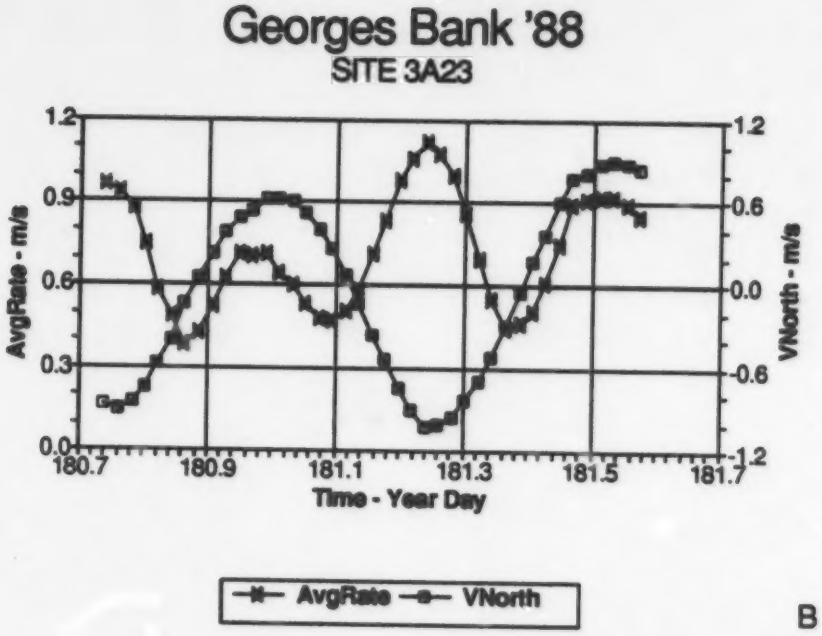
FIGURE 10:

A. Current vector plot for the RCM at 34m depth at site 3 overlapping the EPSONDE anchor station 3A during cruise 88023 (3A23). This anchor station includes EPSONDE stations 1 to 11.

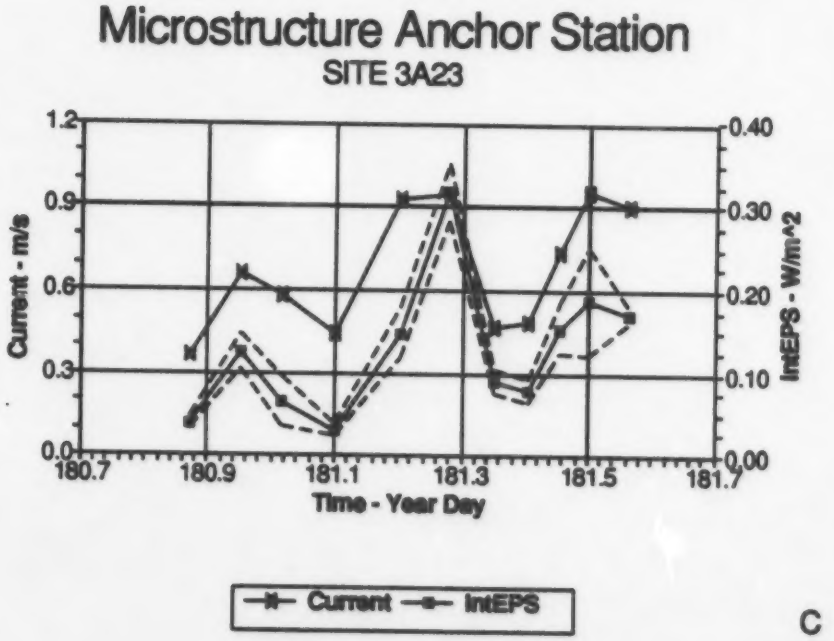
B. The magnitude and the northward component of the vertically averaged composite RCM and Ametek DCP current at half hourly intervals for site 3 coincident with EPSONDE anchor station 3A23.

C. The magnitude of the vertically averaged composite current interpolated to the mean EPSONDE station time and the integrated dissipation, IntEPS, for each EPSONDE station during anchor station 3A23. Error limits are indicated for IntEPS.




Georges Bank '88
SITE 3A23
AvgRate - m/s
VNorth - m/s
Time - Year Day
AvgRate
VNorth

B

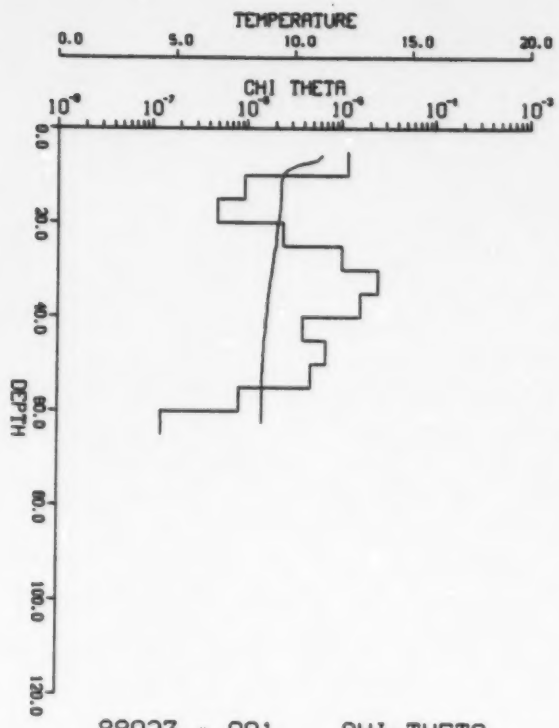

Microstructure Anchor Station
SITE 3A23
Current - m/s
IntEPS - W/m^2
Time - Year Day
Current
IntEPS

C

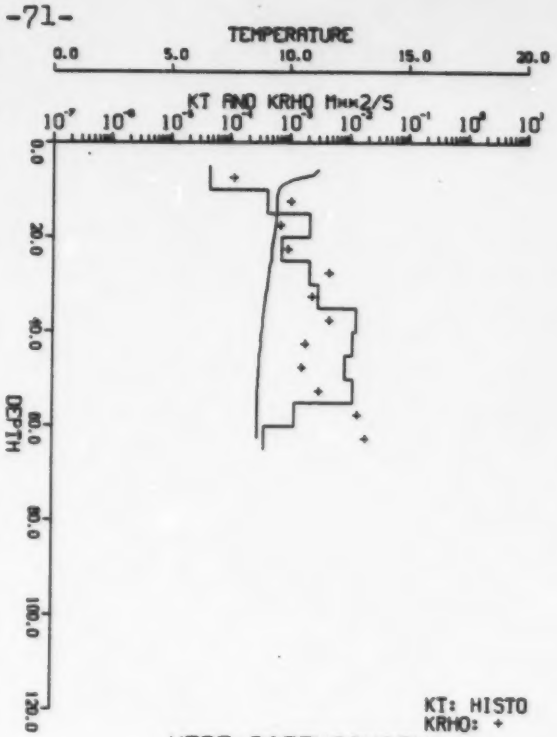
FIGURE 11: Profiles of microstructure quantities for stations 1 to 11 for anchor station 3A23.
- Each page contains a profile of a microstructure quantity averaged over 5 m vertical bins overlaid on a profile of temperature.
- The upper left panel is Chi-Theta, the dissipation of temperature variance.
- The upper right panel contains profiles of vertical diffusivity KT (for temperature) and KRHO for density.
- The lower left panel contains a profile of dissipation, EPSILON.
- The lower right panel shows the profile for Cox number.

The stations are shown in the following order:

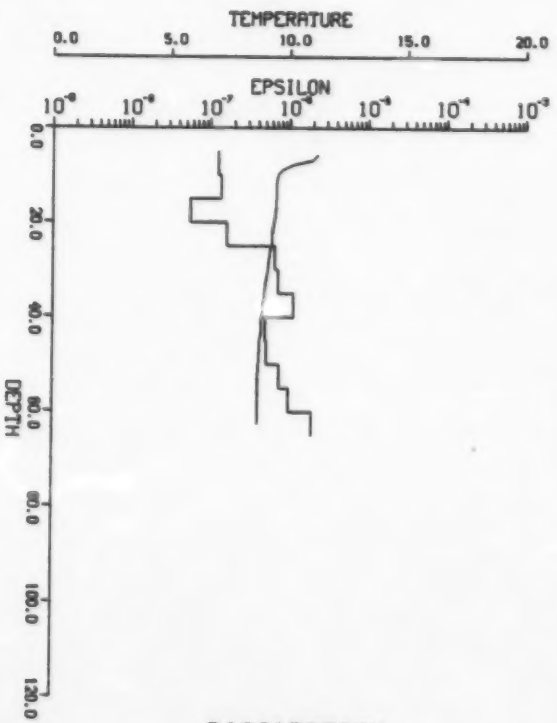
A. Station 1
B. Station 2
C. Station 3
D. Station 4
E. Station 5
F. Station 6
G. Station 7
H. Station 8
I. Station 9
J. Station 10
K. Station 11



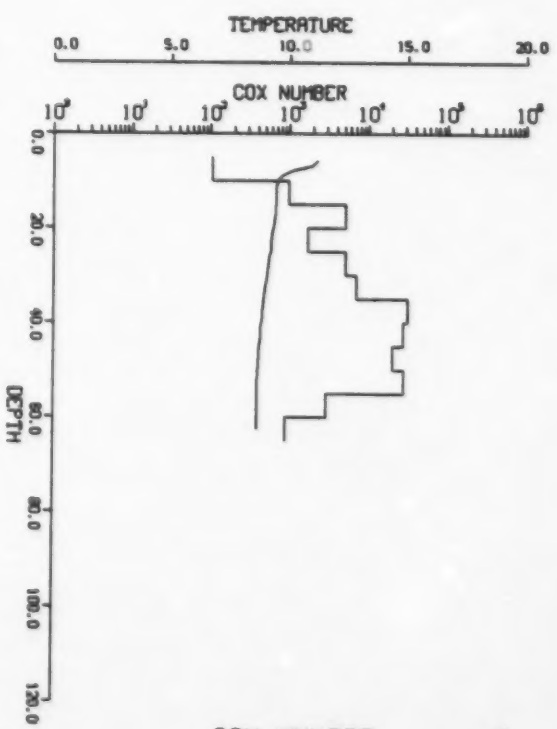

88023 - 001 CHI-THETA



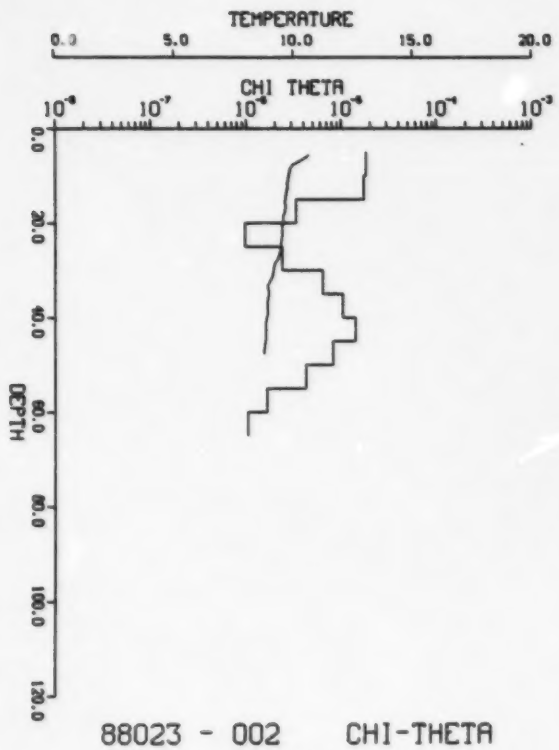

VERT DIFFUSIVITY



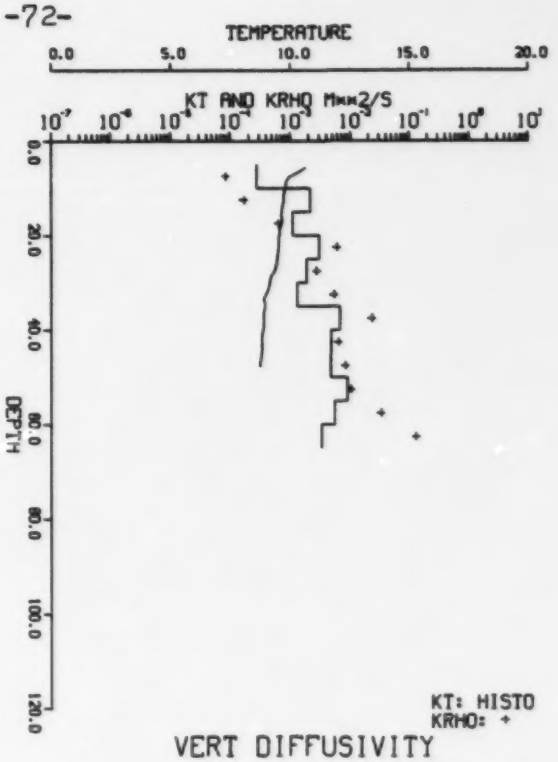

DISSIPATION




COX NUMBER A




88023 - 002 CHI-THETA

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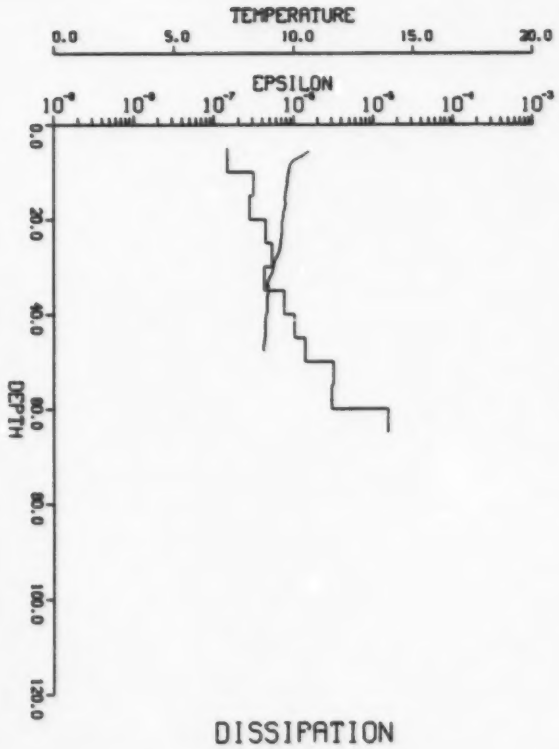


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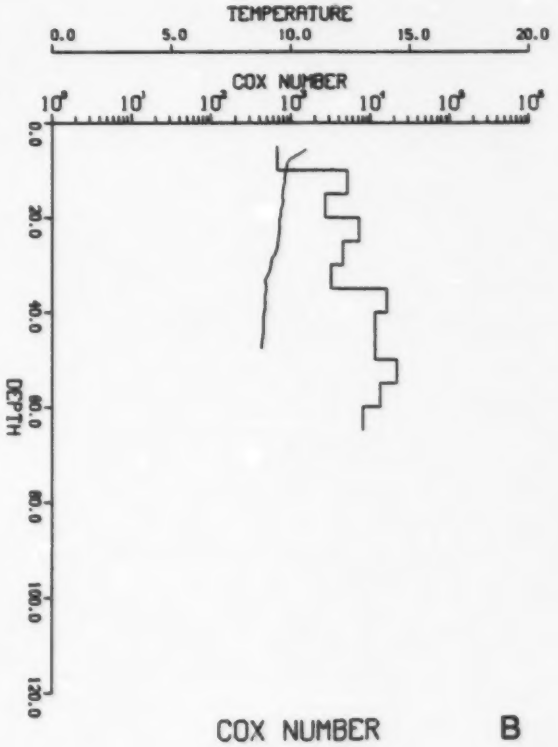


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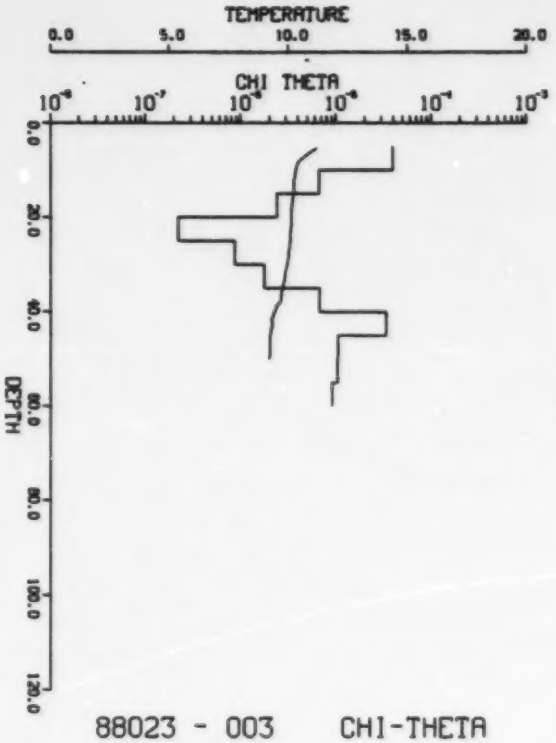
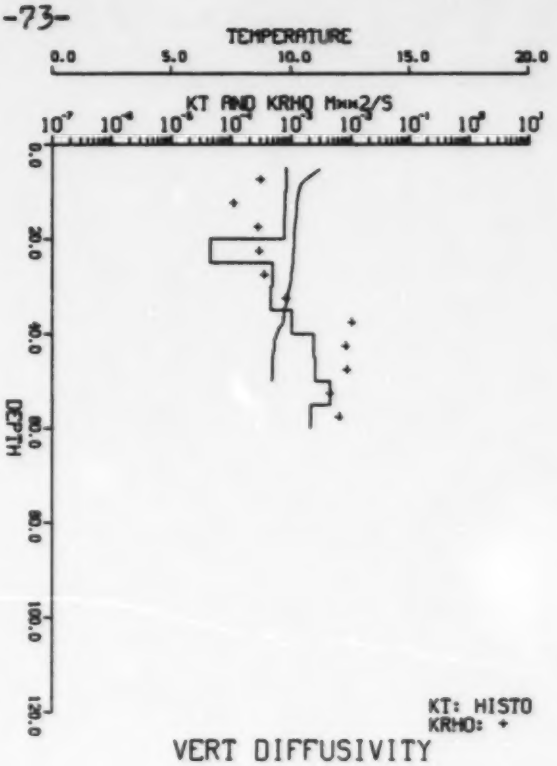



88023 - 003 CHI-THETA

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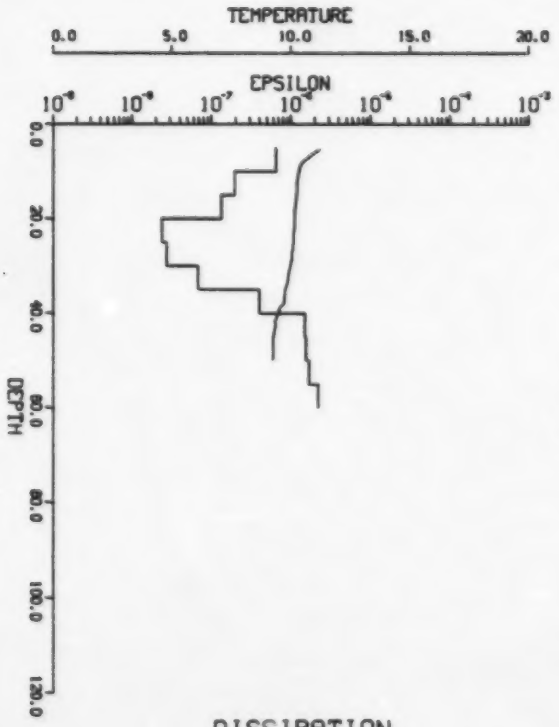


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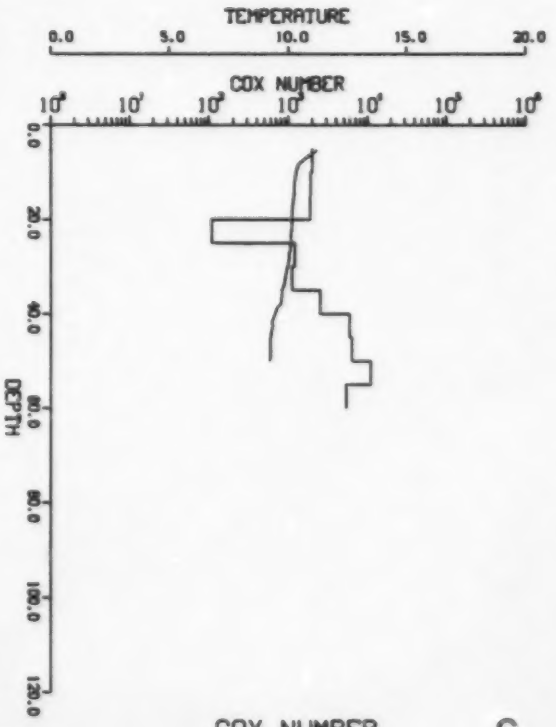
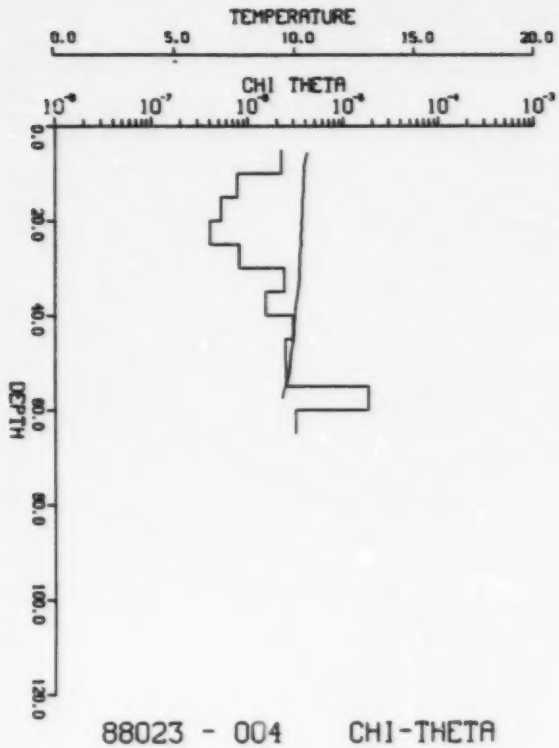
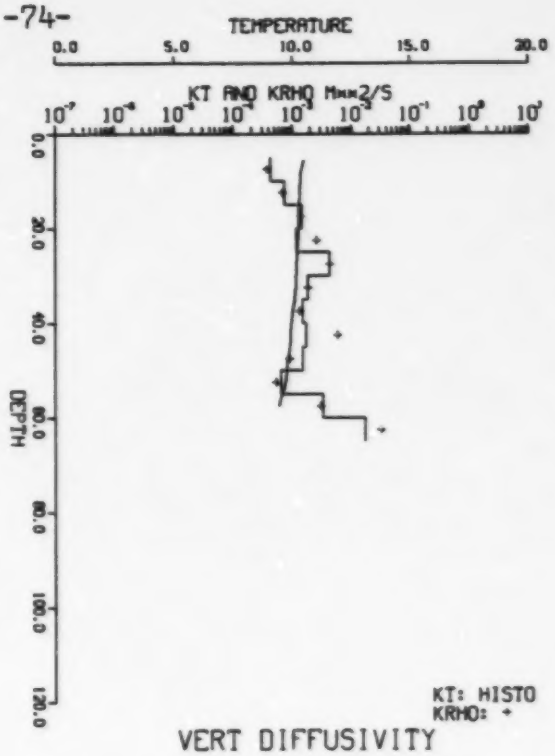



COX NUMBER

C




88023 - 004 CHI-THETA

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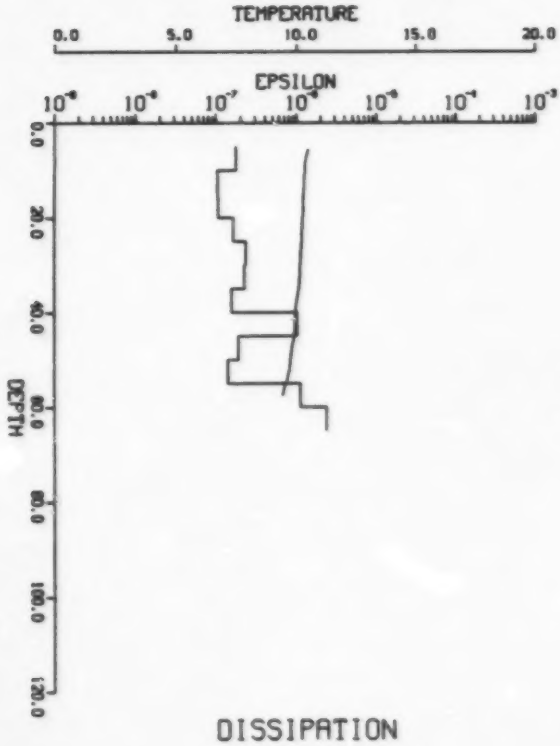


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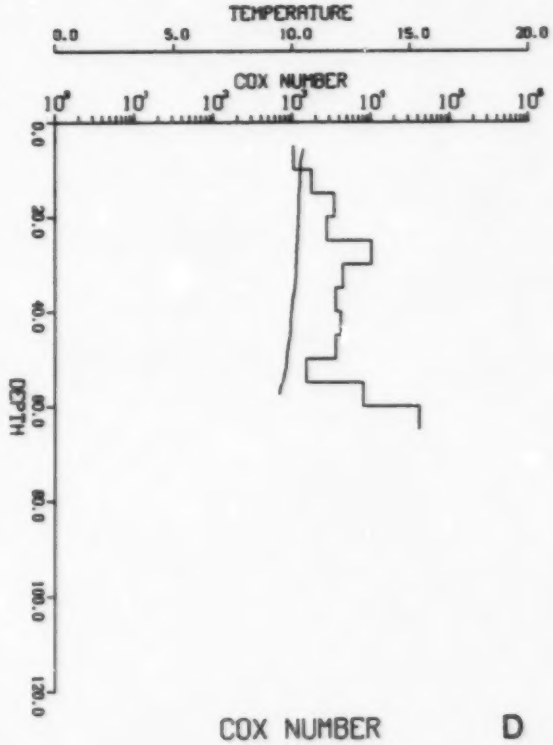


COX NUMBER

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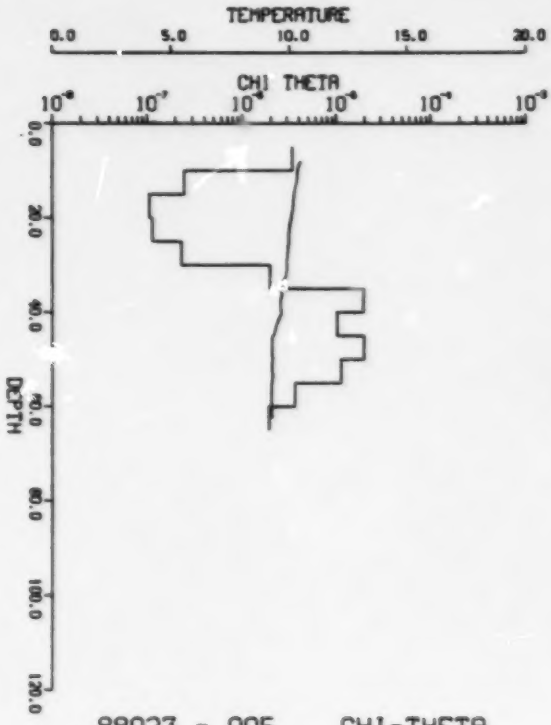
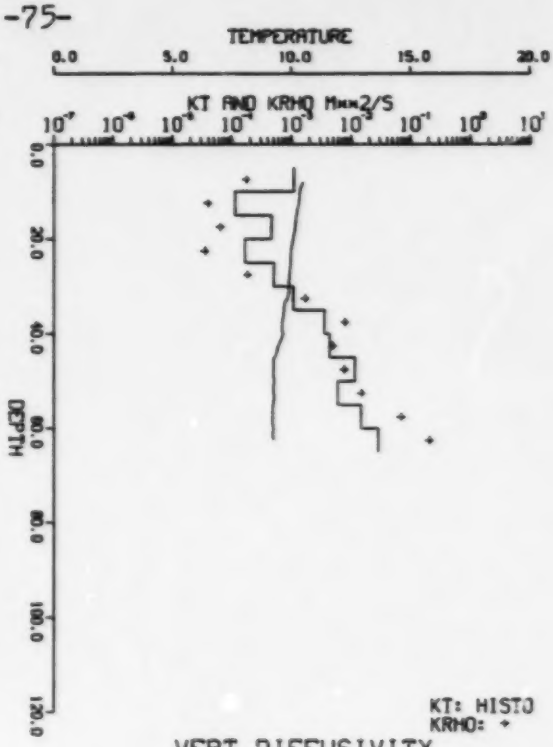



88023 - 005 CHI-THETA

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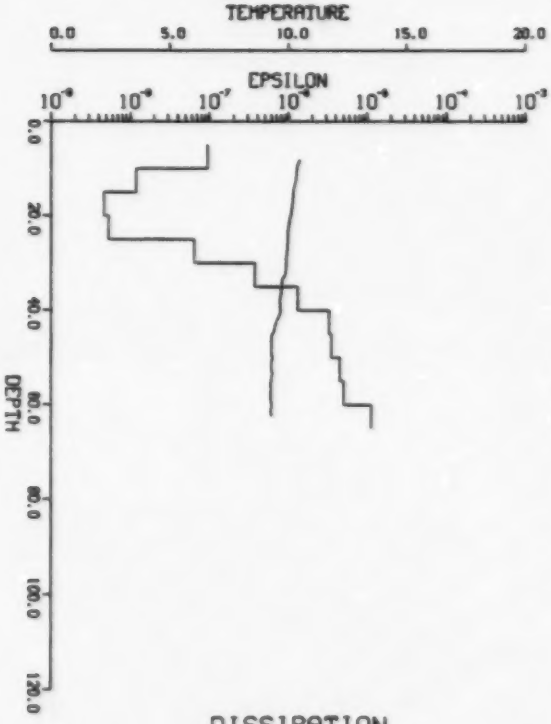


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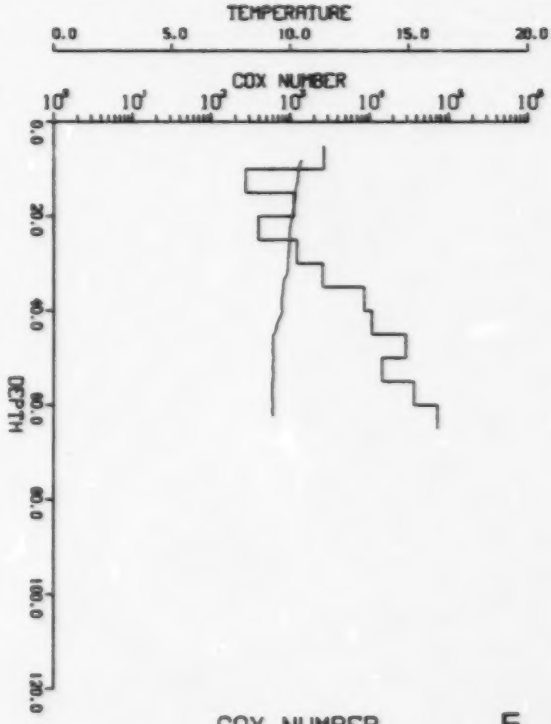


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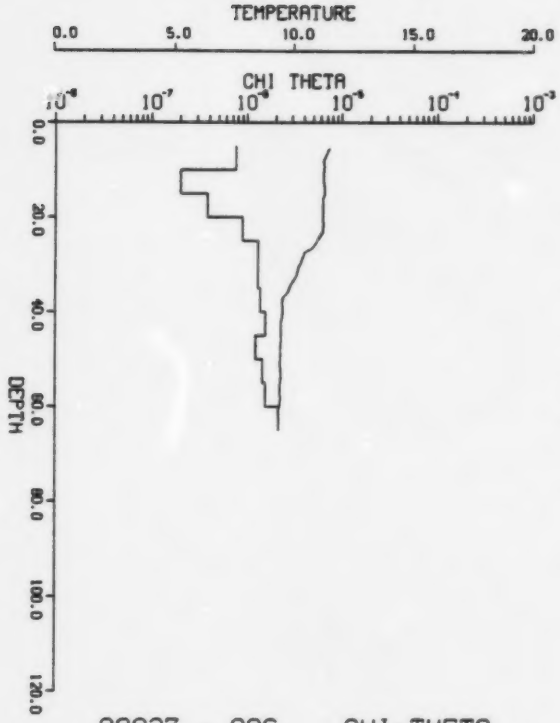
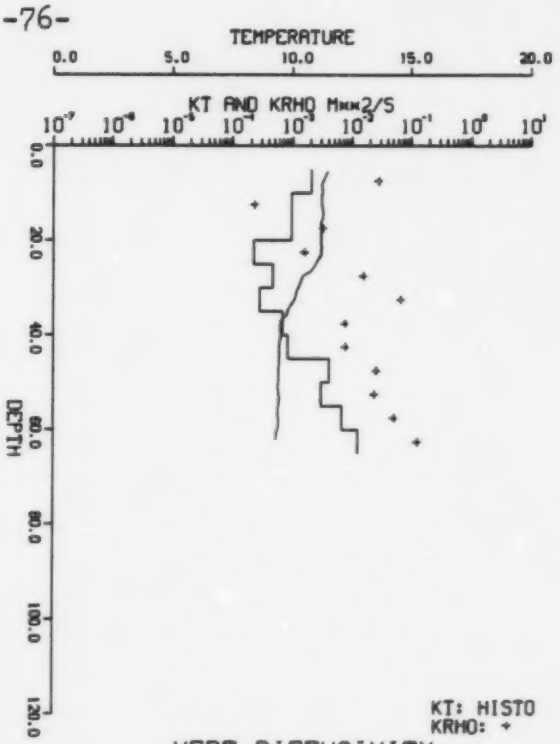



88023 - 006 CHI-THETA

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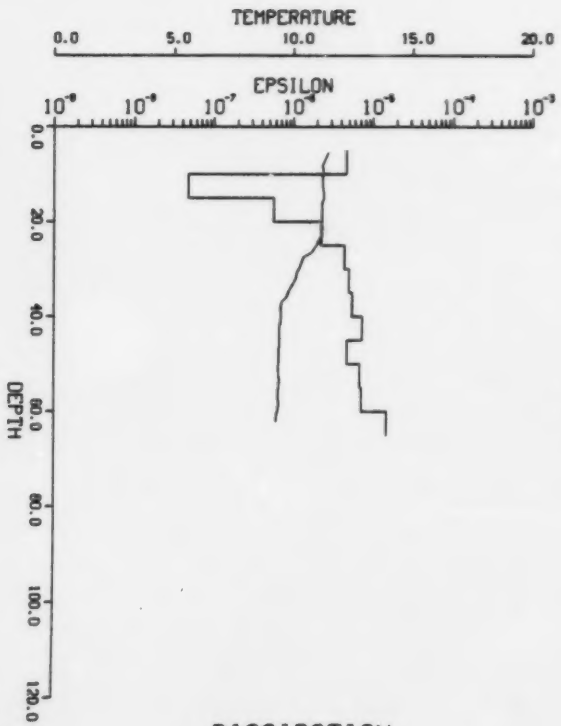


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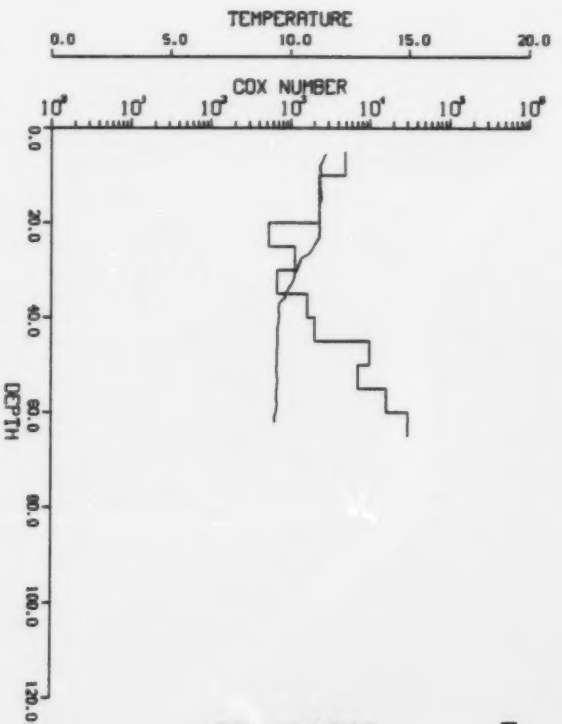


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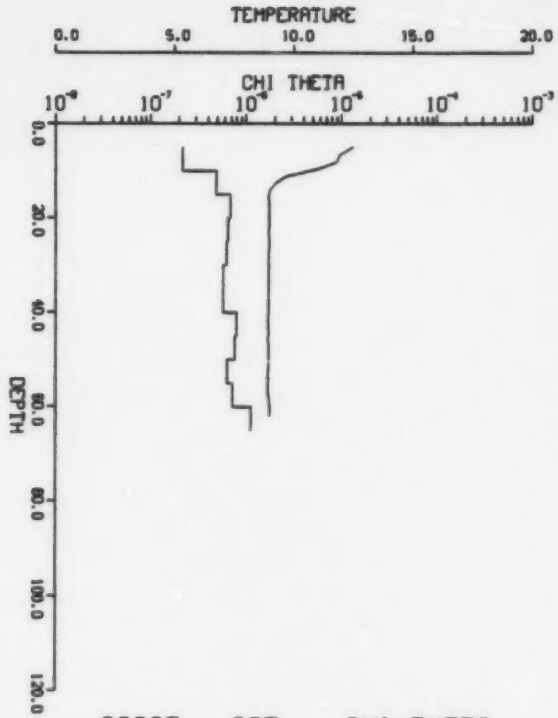
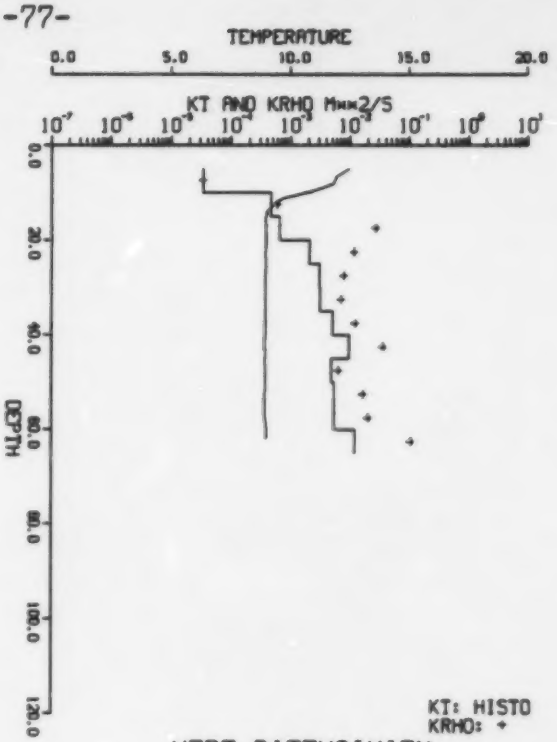



88023 - 007 CHI-THETA

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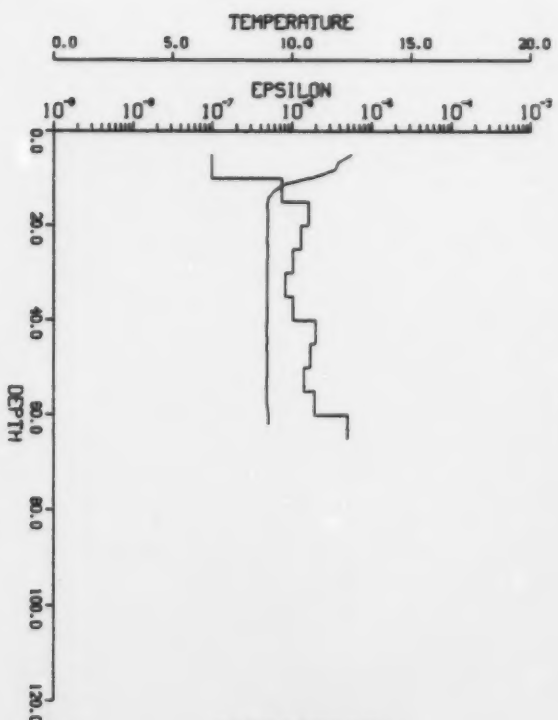


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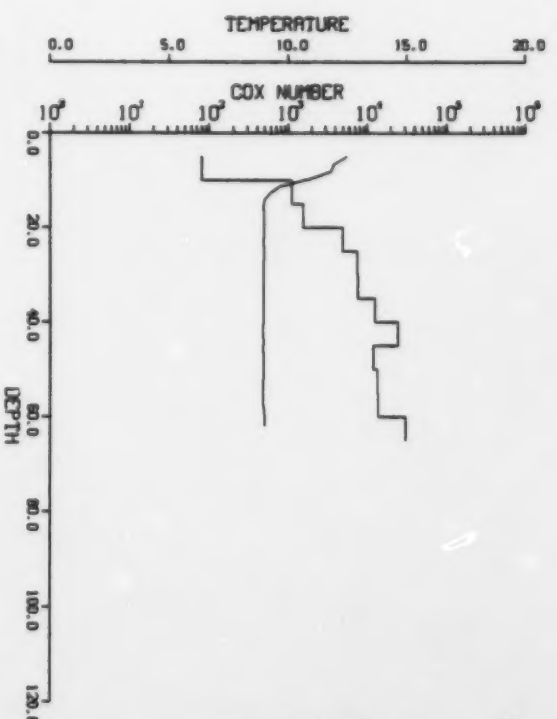


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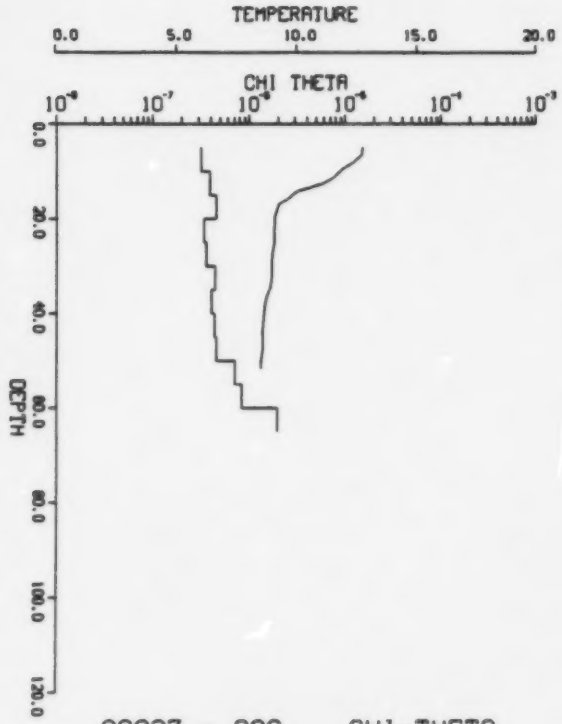
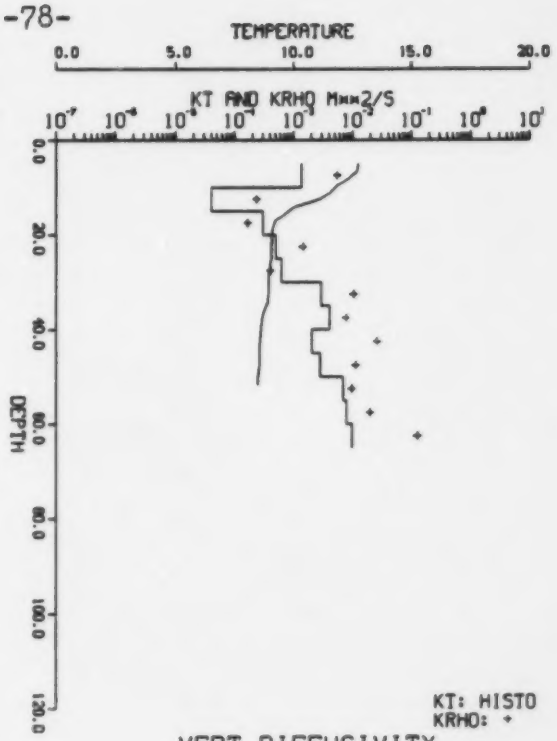



88023 - 008 CHI-THETA

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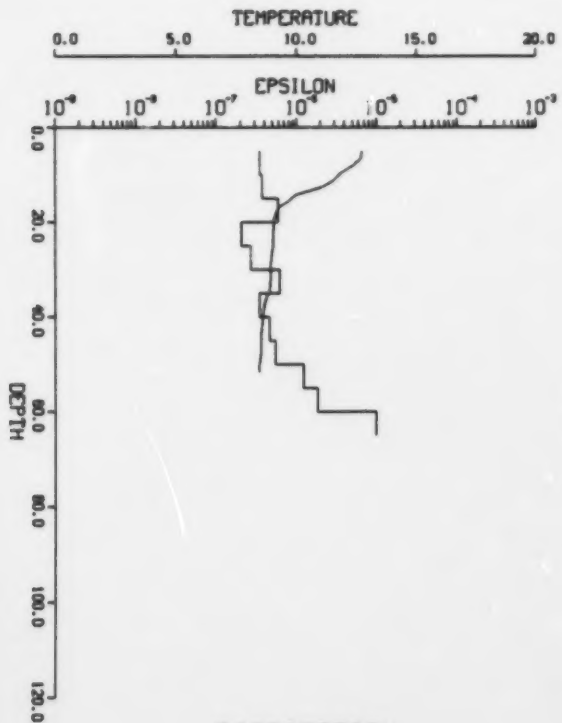
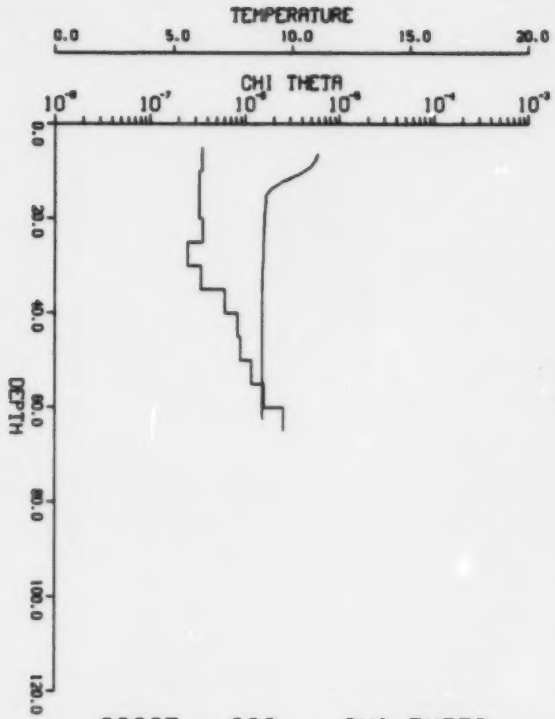
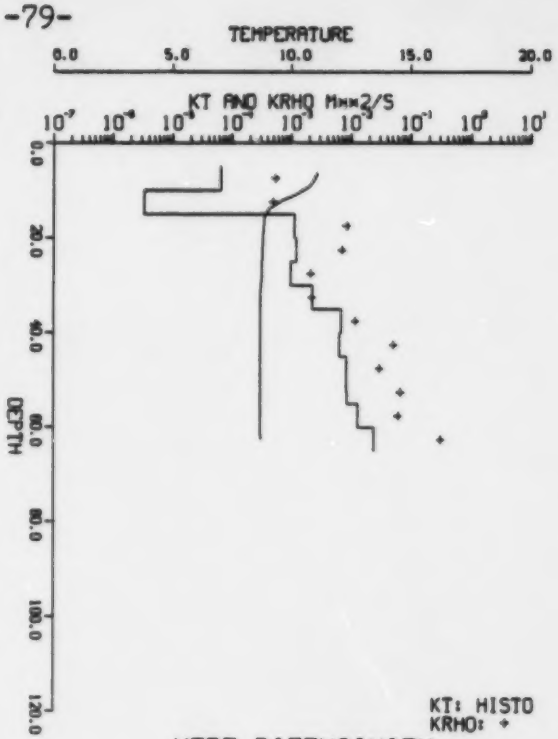



DISSIPATION

COX NUMBER H




88023 - 009 CHI-THETA

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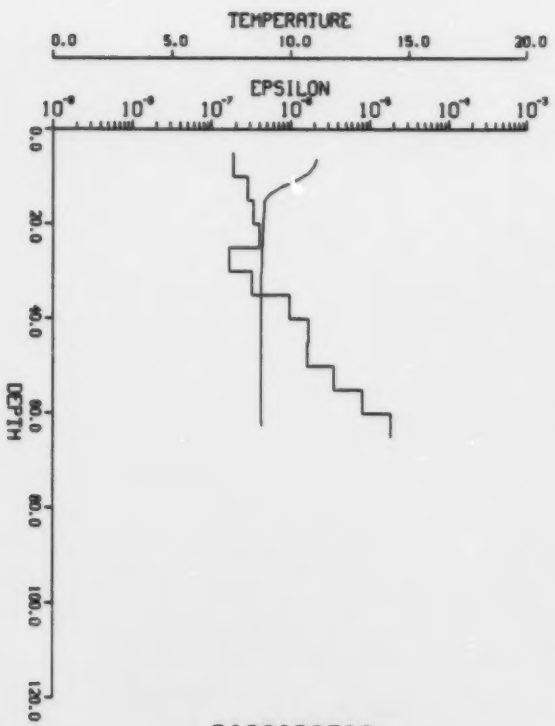


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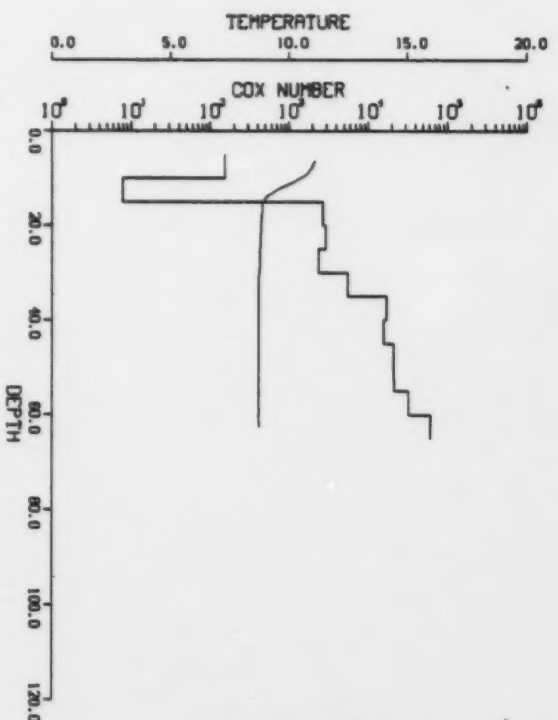


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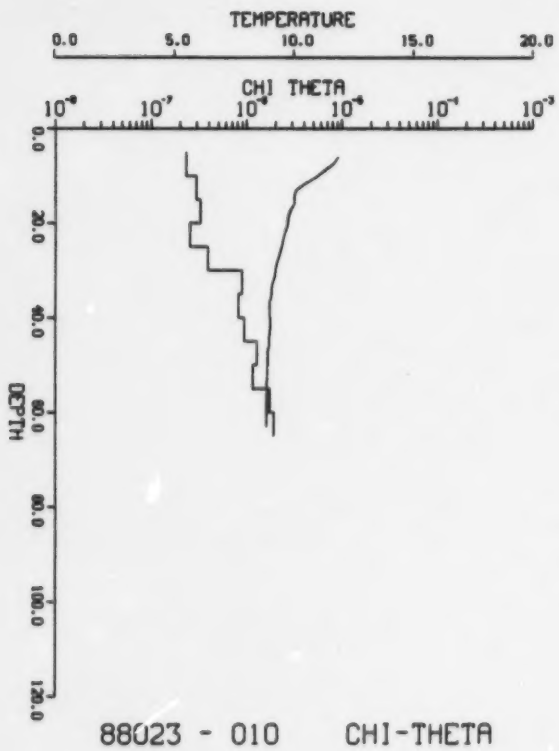
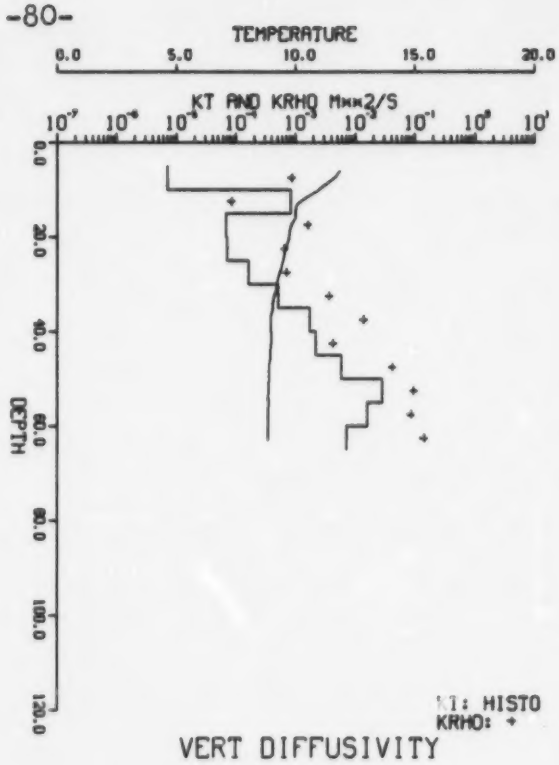



88023 - 010 CHI-THETA

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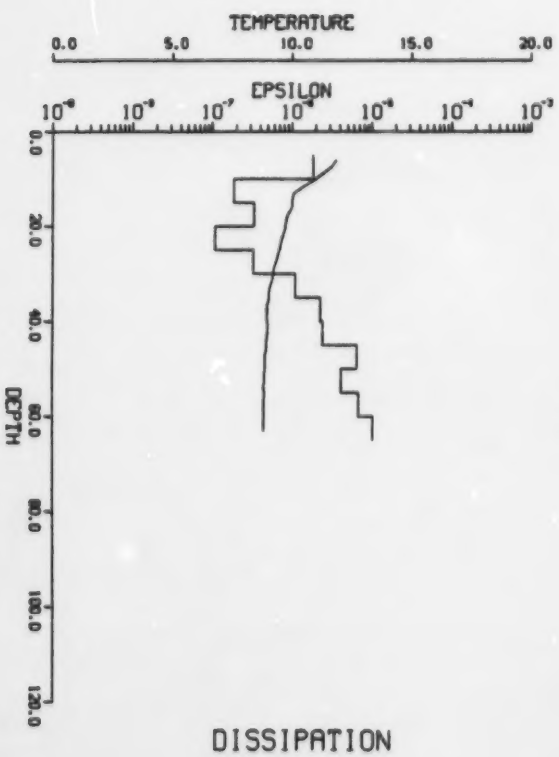


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COX NUMBER

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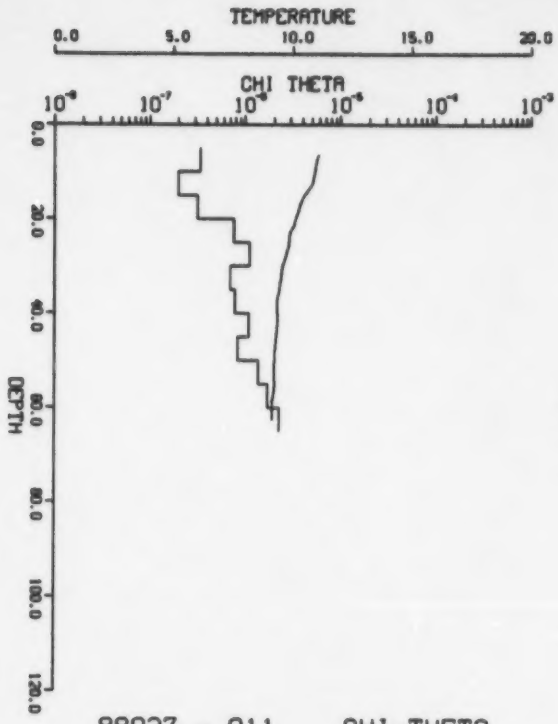
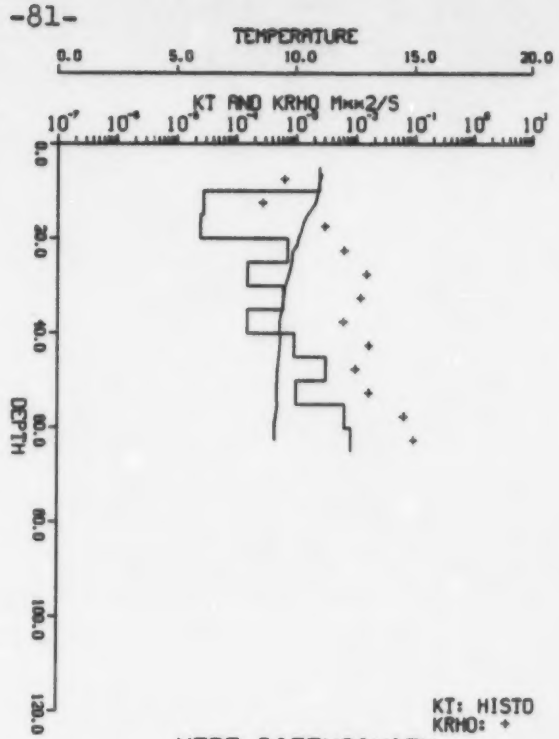



88023 - 011 CHI-THETA

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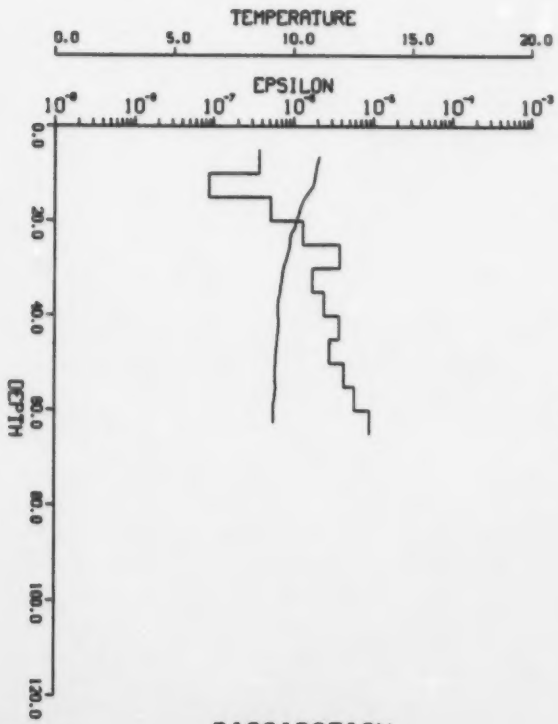


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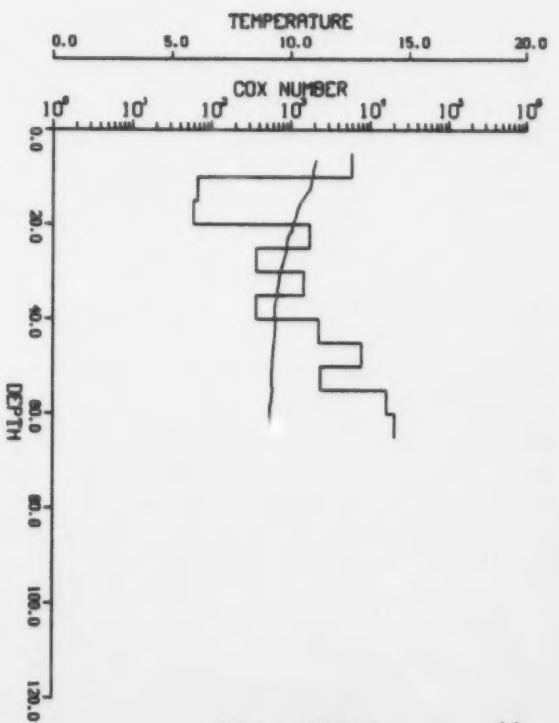



COX NUMBER K

# SITE 3B23

41°59.84N, 66°46.42W

TABLE 5: COMBINED CURRENT AND DISSIPATION

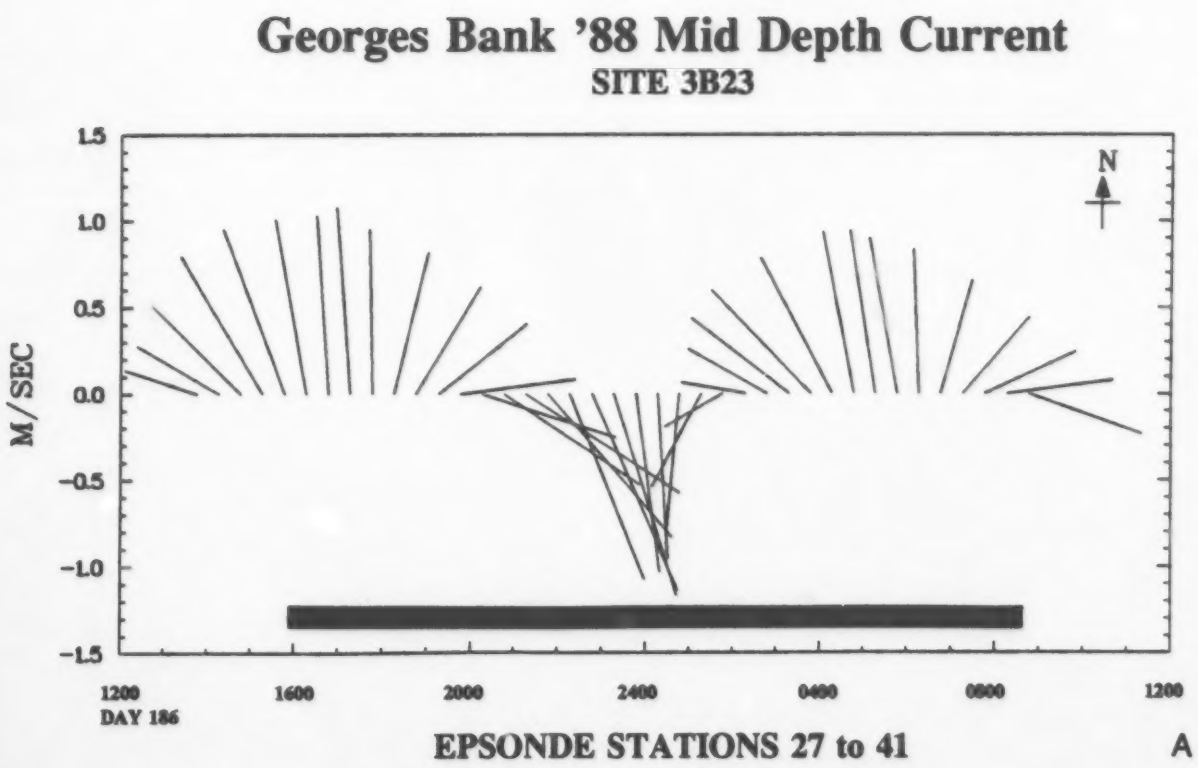
| Station | TimeEPS | Depth | Drops | Current | IntEPS | ErrEPS |
|---|---|---|---|---|---|---|
| E27 | 186.6639 | 63.60 | 5 | 0.969 | 0.2948 | 0.0871 |
| E28 | 186.7049 | 65.35 | 8 | 0.977 | 0.1477 | 0.0207 |
| E29 | 186.7653 | 66.00 | 6 | 0.801 | 0.1755 | 0.0406 |
| E30 | 186.8007 | 66.00 | 8 | 0.642 | 0.2155 | 0.0362 |
| E31 | 186.8476 | 66.00 | 8 | 0.735 | 0.1266 | 0.0173 |
| E32 | 186.8837 | 64.40 | 8 | 0.973 | 0.2679 | 0.0707 |
| E33 | 186.9243 | 66.00 | 8 | 1.174 | 0.3737 | 0.0382 |
| E34 | 186.9719 | 64.90 | 8 | 1.193 | 0.4329 | 0.0753 |
| E36 | 187.0660 | 62.20 | 1 | 0.527 | 0.2218 | 0.0446 |
| E37 | 187.1552 | 66.00 | 8 | 0.734 | 0.2222 | 0.0407 |
| E38 | 187.2045 | 65.45 | 5 | 0.842 | 0.1802 | 0.0289 |
| E39 | 187.2708 | 66.00 | 6 | 0.654 | 0.0689 | 0.0059 |
| E40 | 187.3132 | 66.00 | 7 | 0.500 | 0.0599 | 0.0064 |
| E41 | 187.3524 | 66.00 | 8 | 0.570 | 0.1375 | 0.0758 |

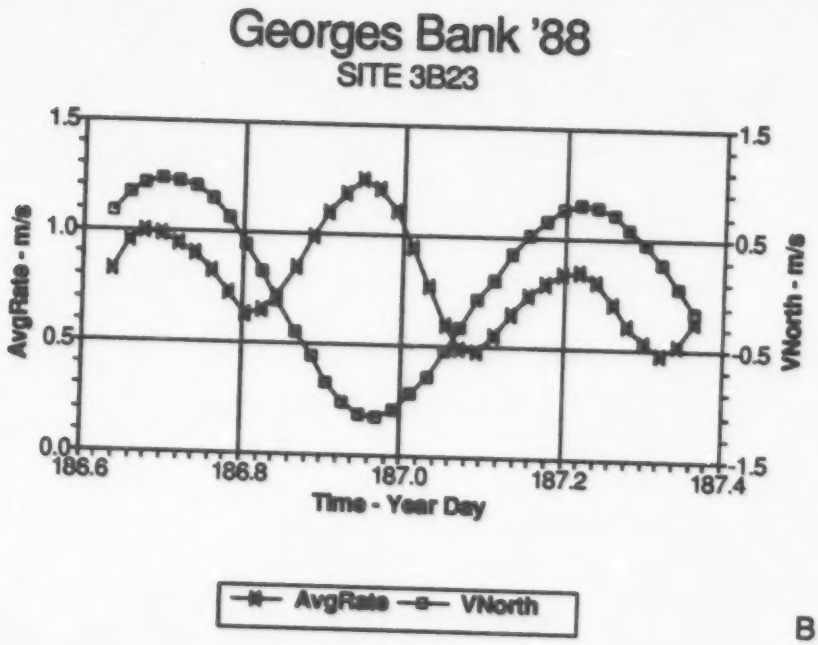
FIGURE 12:

A. Current vector plot for the RCM at 34m depth at site 3 overlapping the EPSONDE anchor station 3B during cruise 88023 (3B23). This anchor station includes EPSONDE stations 27 to 41.

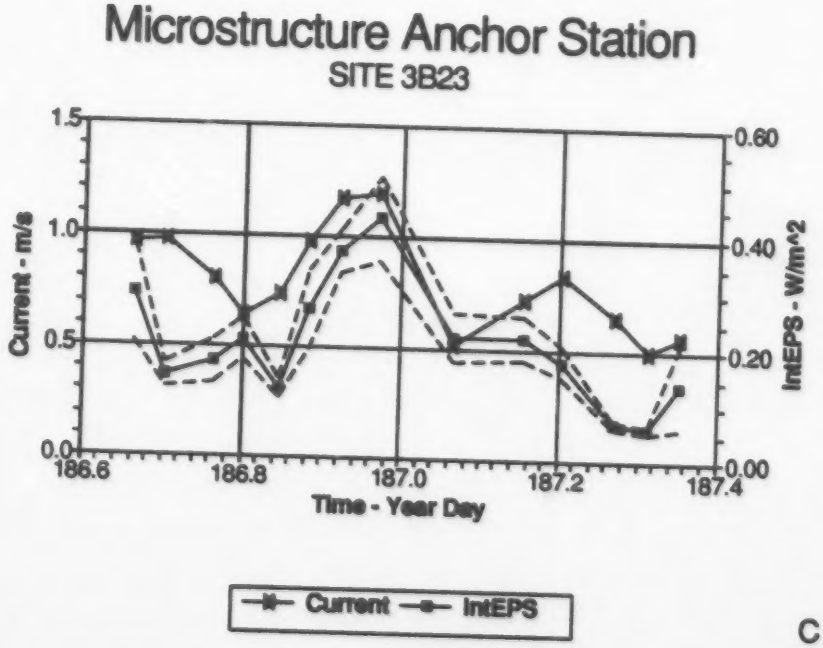
B. The magnitude and the northward component of the vertically averaged composite RCM and Ametek DCP current at half hourly intervals for site 3 coincident with EPSONDE anchor station 3B23.

C. The magnitude of the vertically averaged composite current interpolated to the mean EPSONDE station time and the integrated dissipation, IntEPS, for each EPSONDE station during anchor station 3B23. Error limits are indicated for IntEPS.




Georges Bank '88
SITE 3B23
AvgRate - m/s
VNorth - m/s
Time - Year Day
AvgRate
VNorth

B

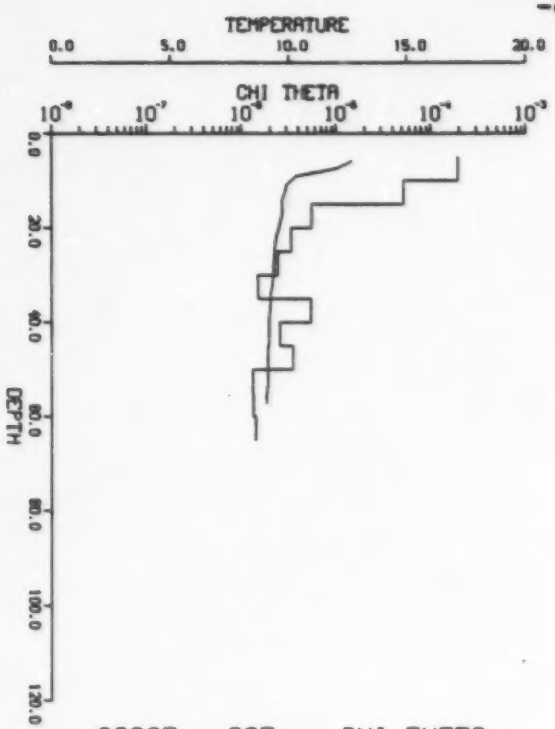

Microstructure Anchor Station
SITE 3B23
Current - m/s
IntEPS - W/m^2
Time - Year Day
Current
IntEPS

C

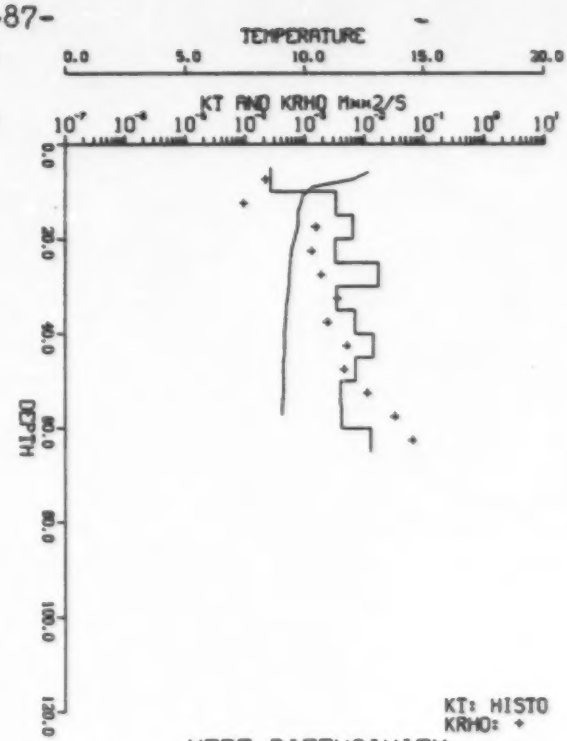
FIGURE 13: Profiles of microstructure quantities for stations 27 to 41 for anchor station 3B23.
- Each page contains a profile of a microstructure quantity averaged over 5 m vertical bins overlaid on a profile of temperature.
- The upper left panel is Chi-Theta, the dissipation of temperature variance.
- The upper right panel contains profiles of vertical diffusivity KT (for temperature) and KRHO for density.
- The lower left panel contains a profile of dissipation, EPSILON.
- The lower right panel shows the profile for Cox number.

The stations are shown in the following order:

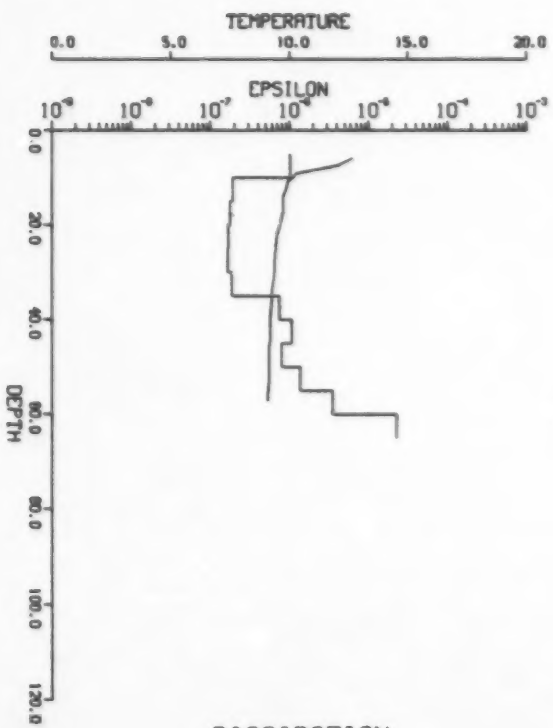
A. Station 27
B. Station 28
C. Station 29
D. Station 30
E. Station 31
F. Station 32
G. Station 33
H. Station 34
I. Station 36
J. Station 37
K. Station 38
L. Station 39
M. Station 40
N. Station 41



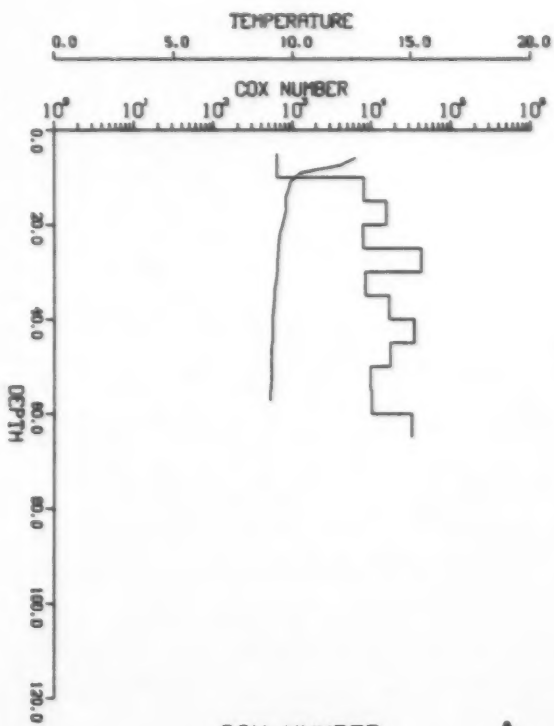

88023 - 027 CHI-THETA



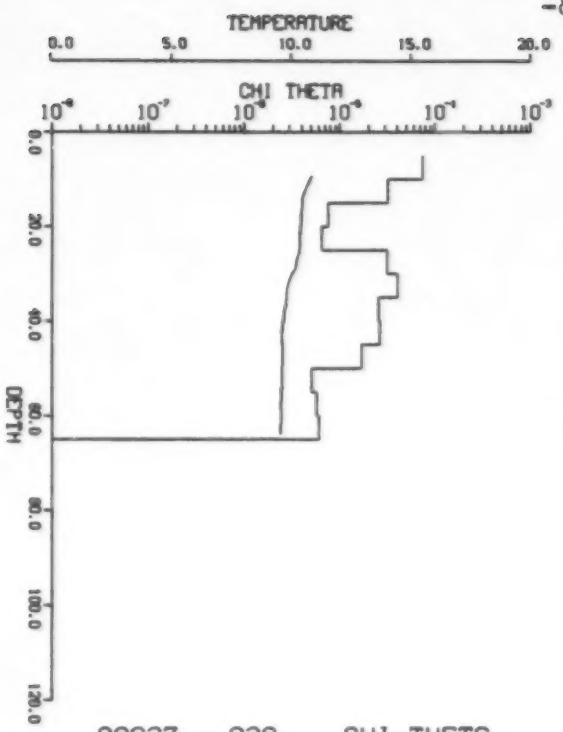

VERT DIFFUSIVITY



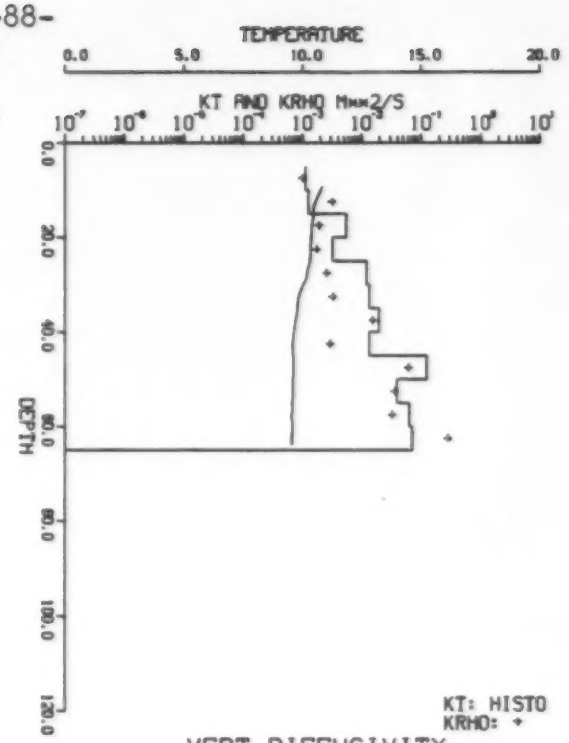

DISSIPATION




COX NUMBER A




88023 - 028 CHI-THETA

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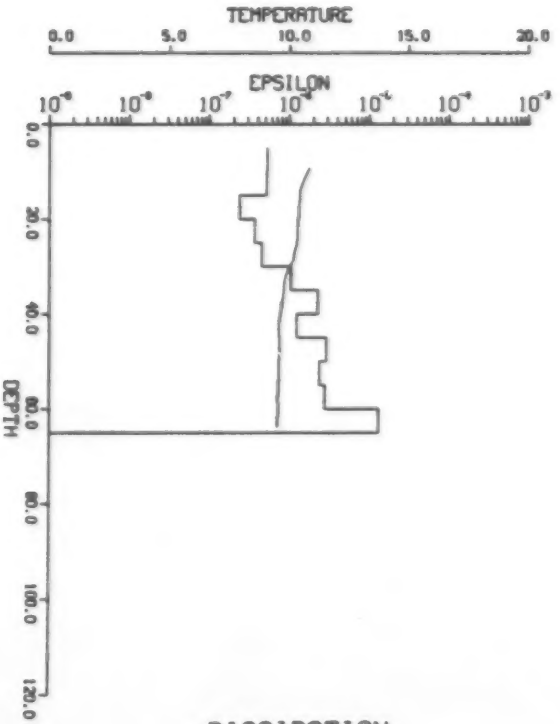


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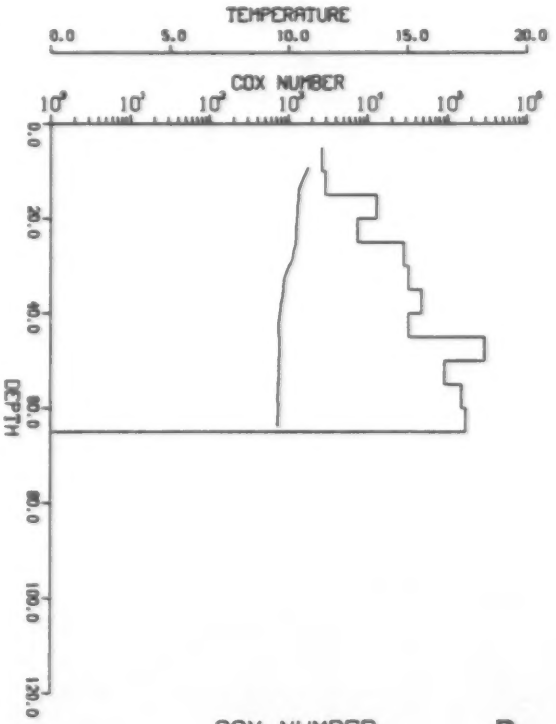


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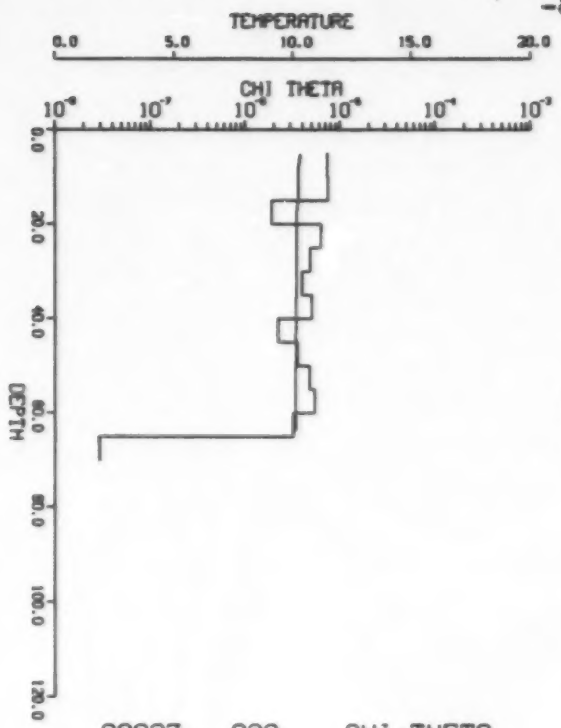
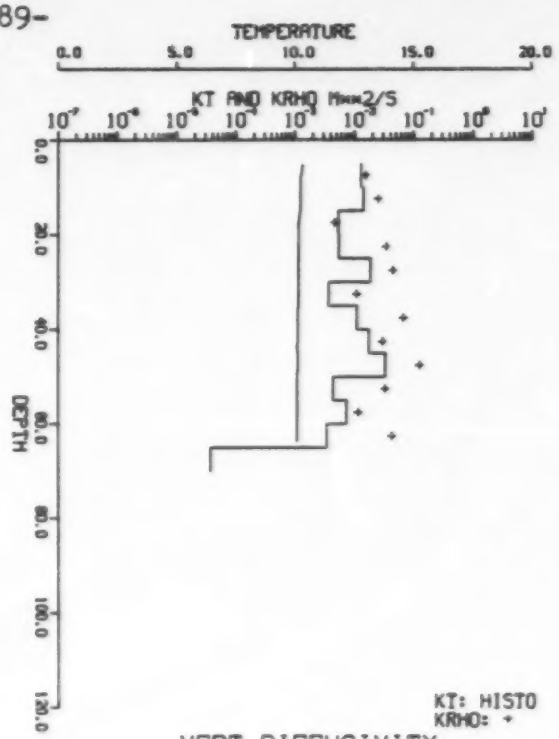



88023 - 029 CHI-THETA

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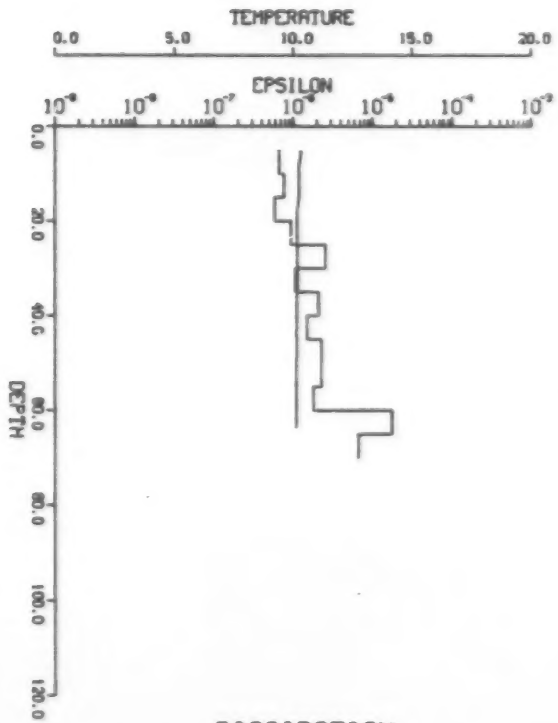


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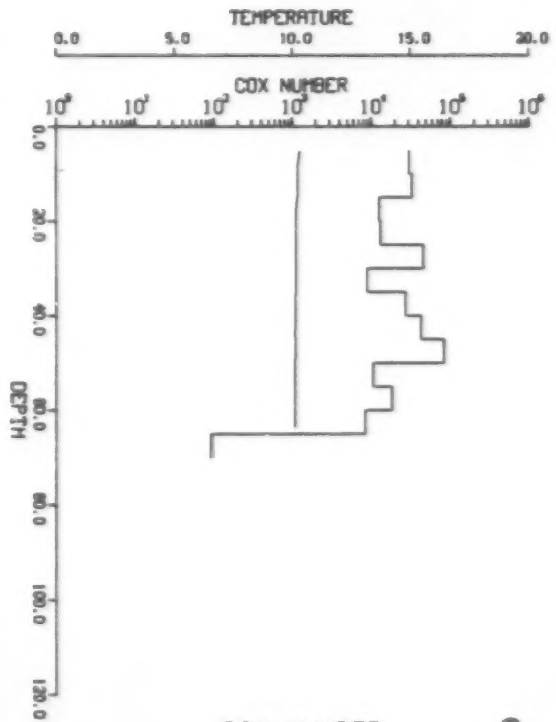


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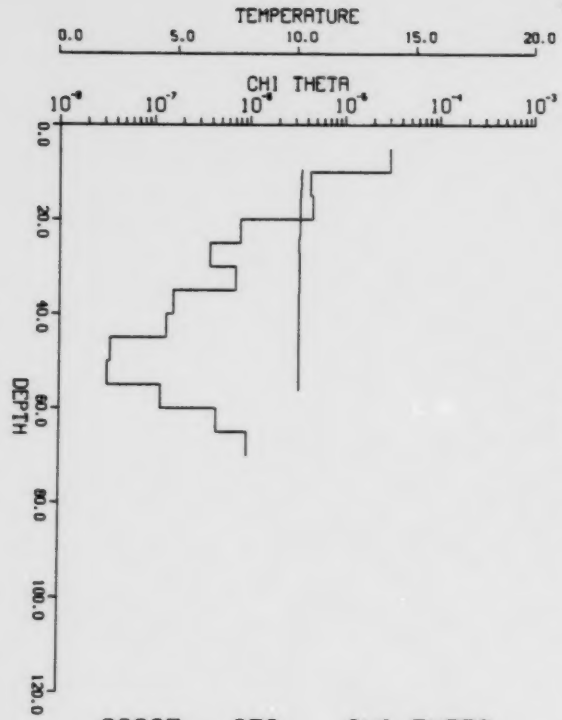
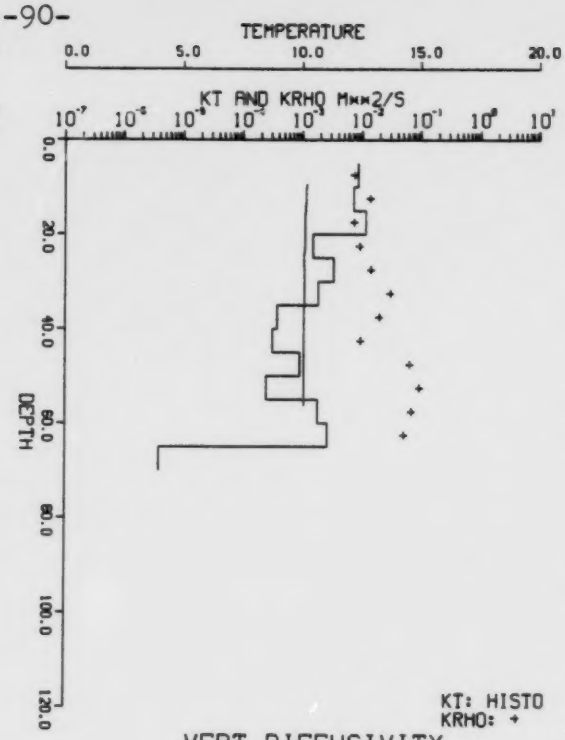



88023 - 030 CHI-THETA

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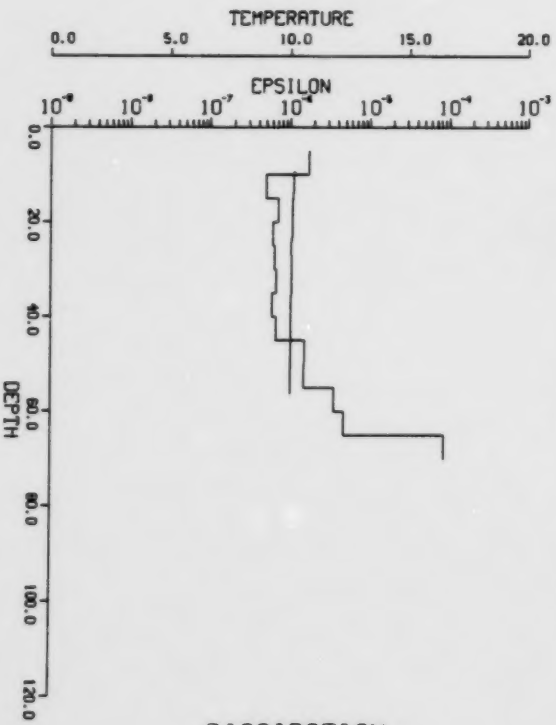


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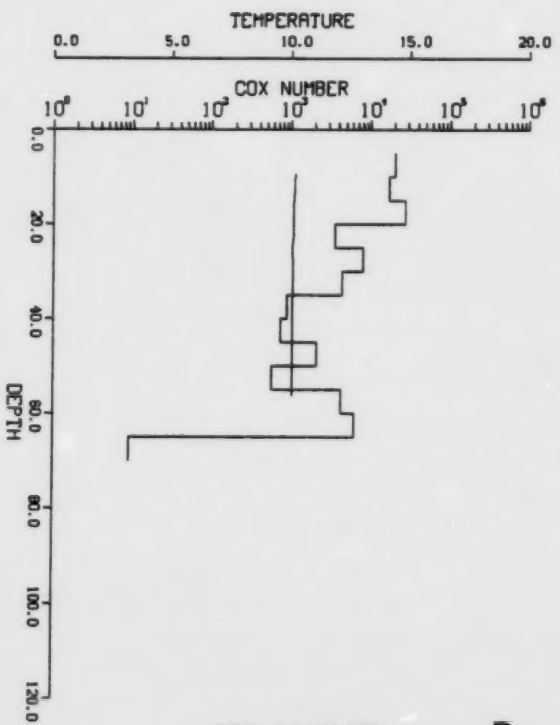


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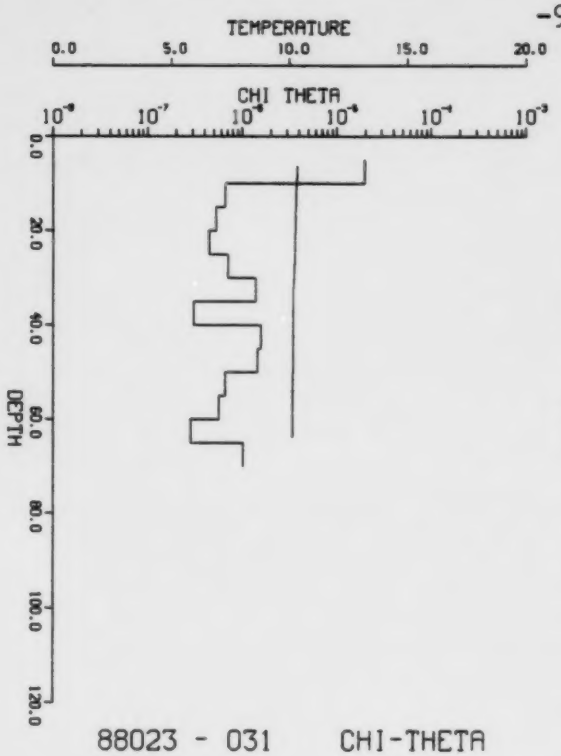
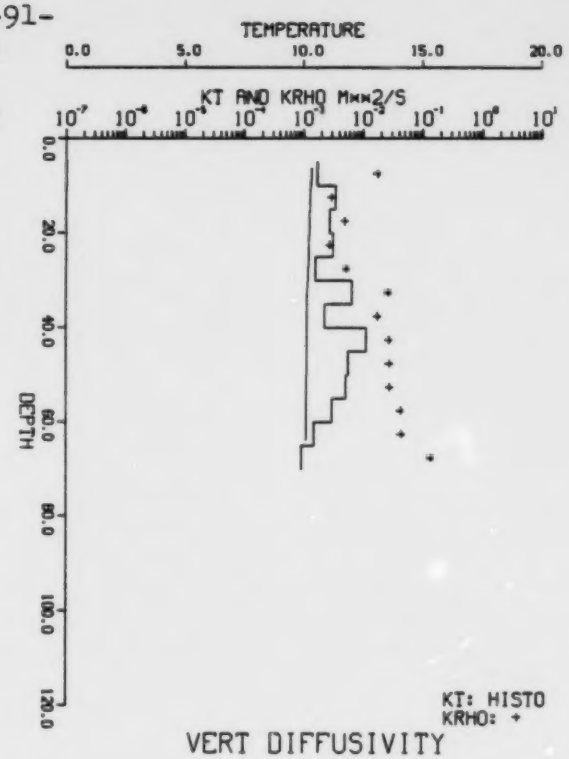



88023 - 031 CHI-THETA

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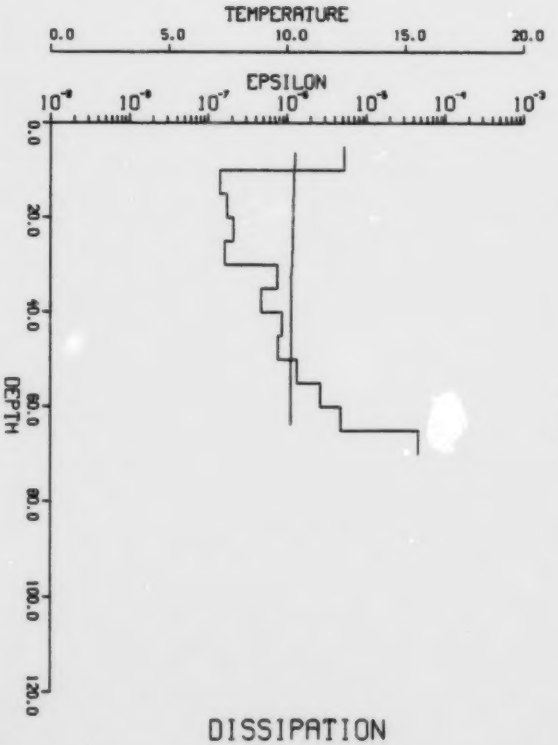


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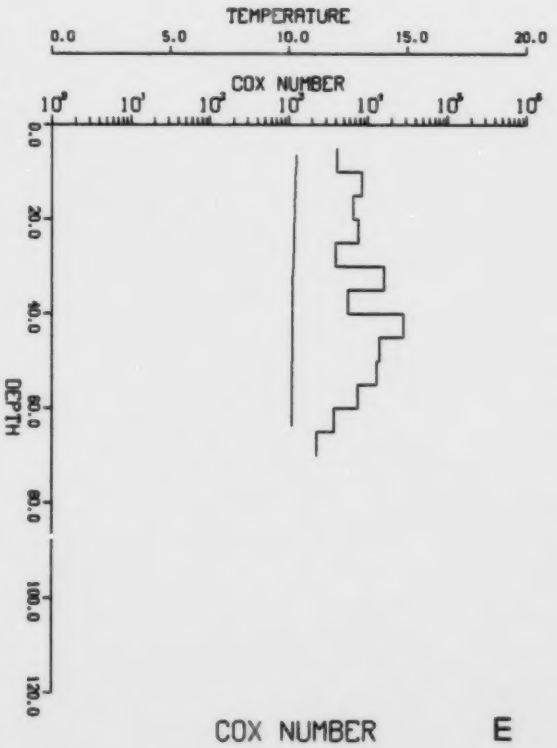


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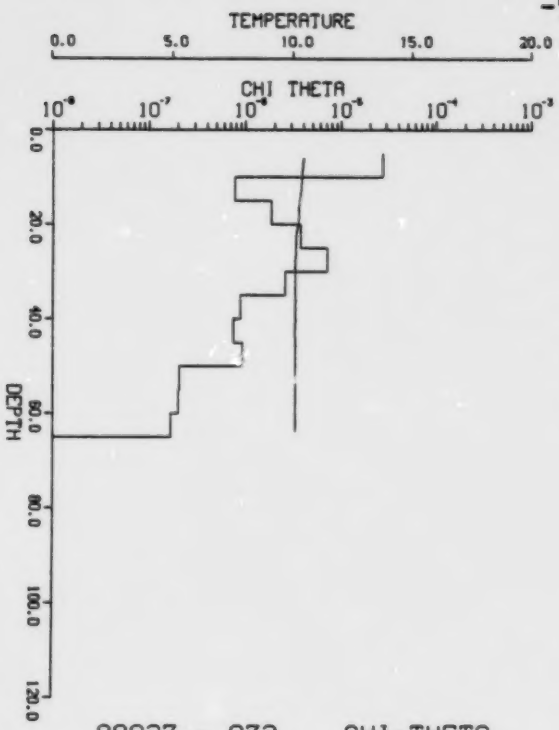
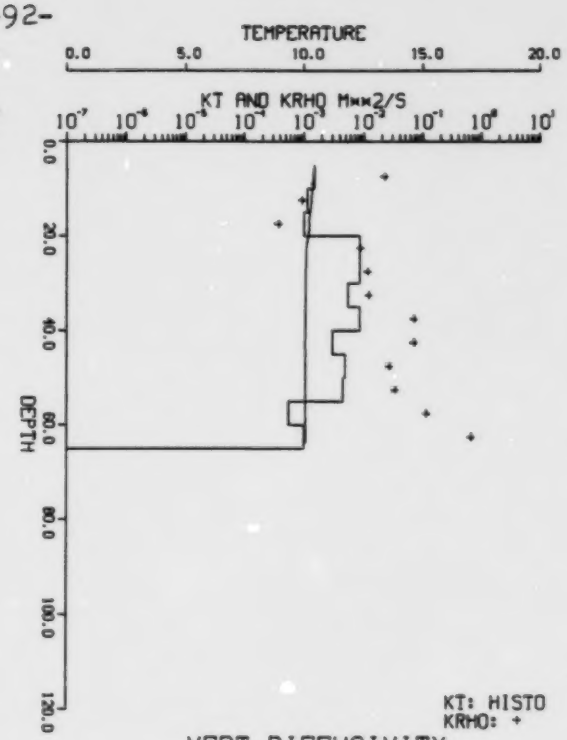



88023 - 032 CHI-THETA

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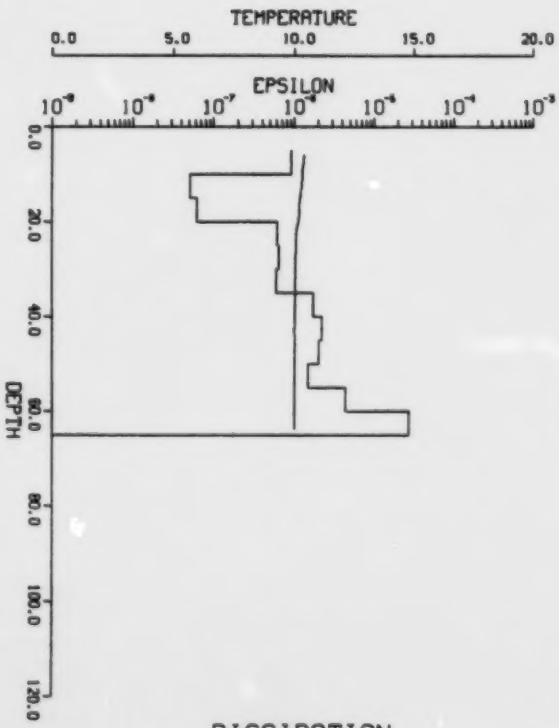


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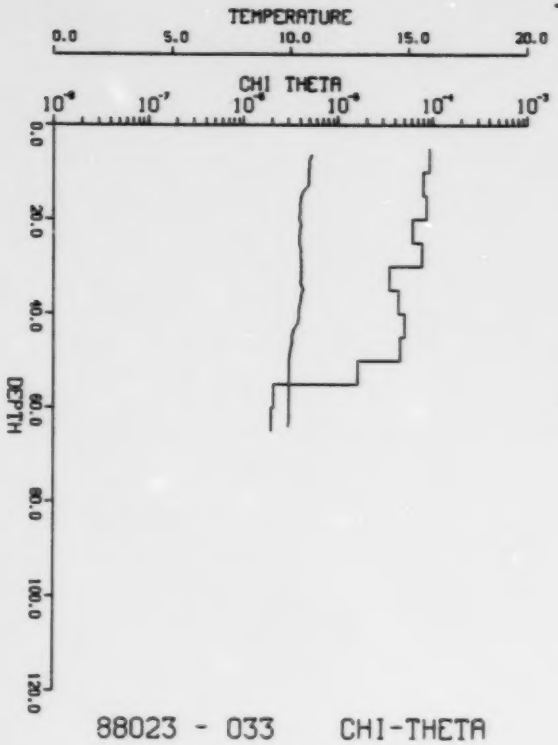
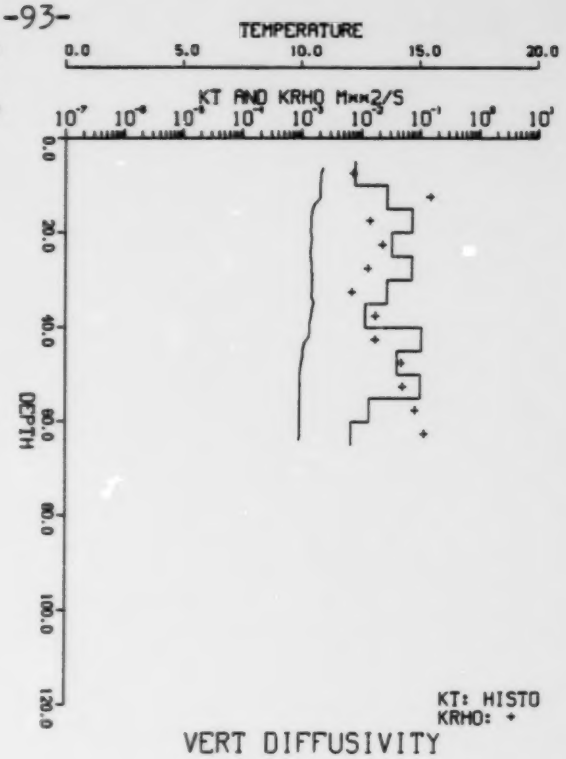



88023 - 033 CHI-THETA

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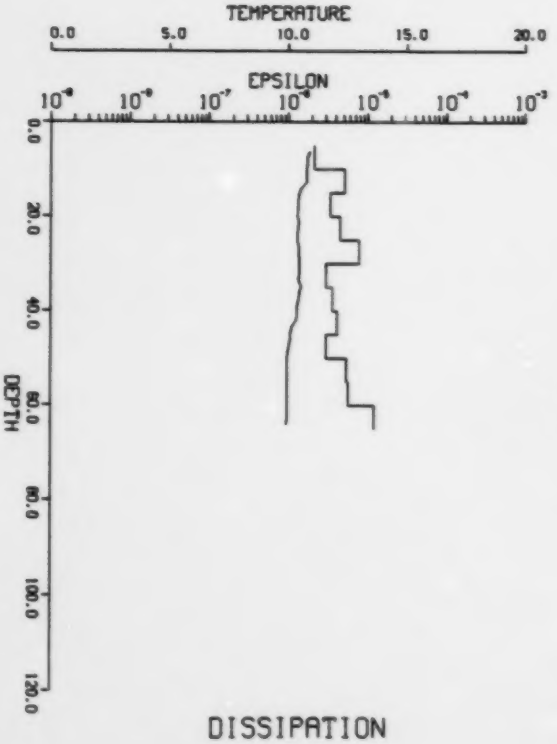


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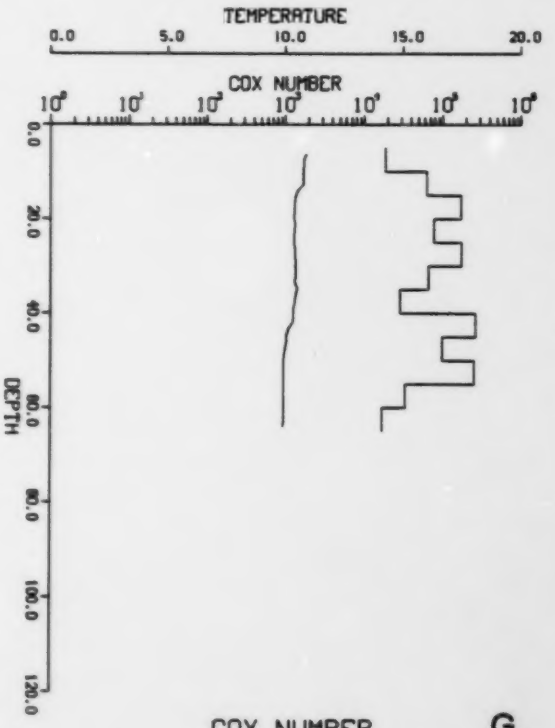


COX NUMBER

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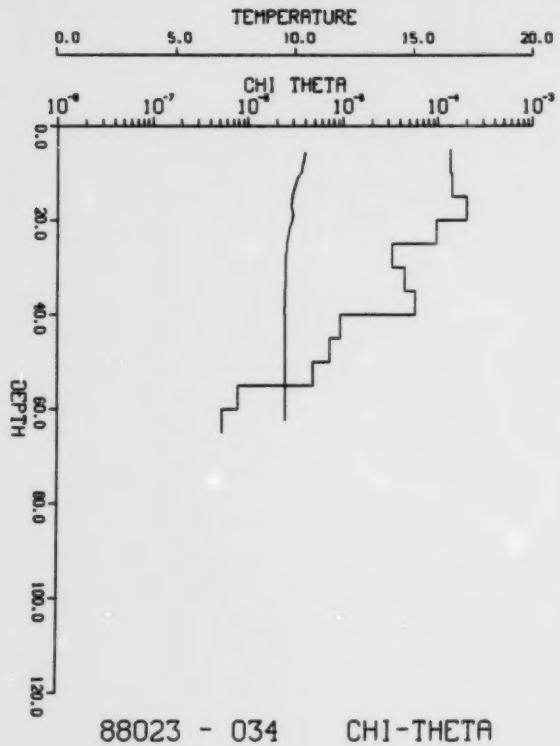
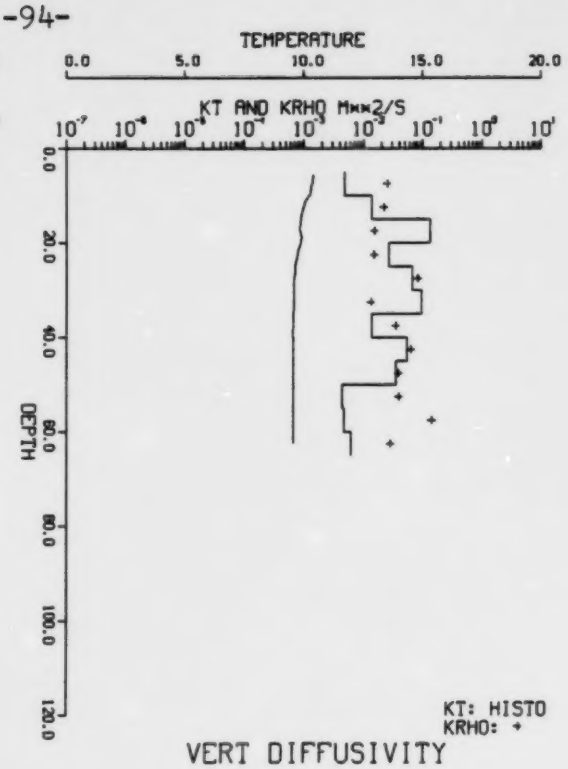



88023 - 034 CHI-THETA

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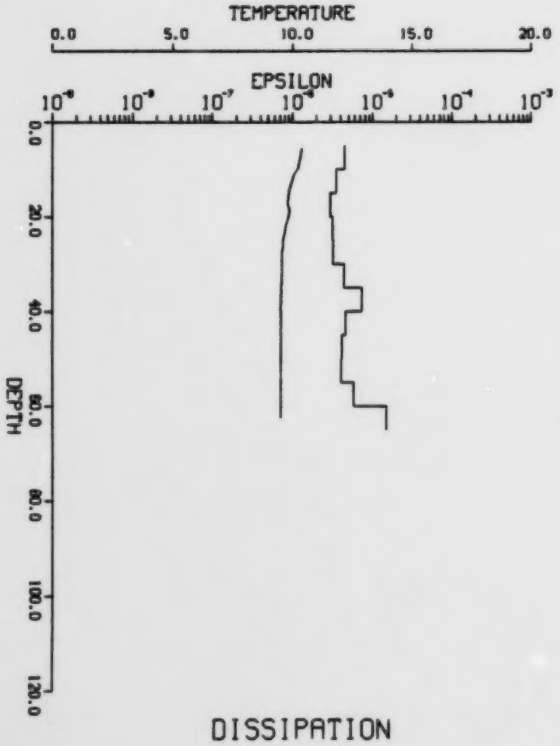


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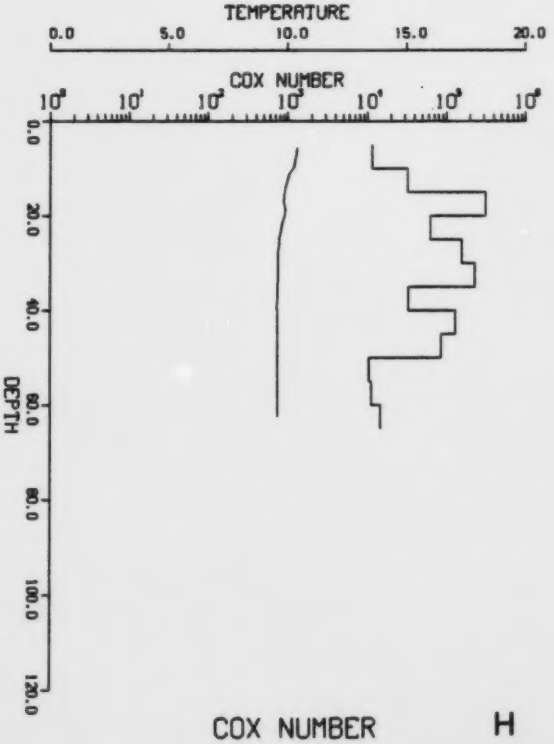
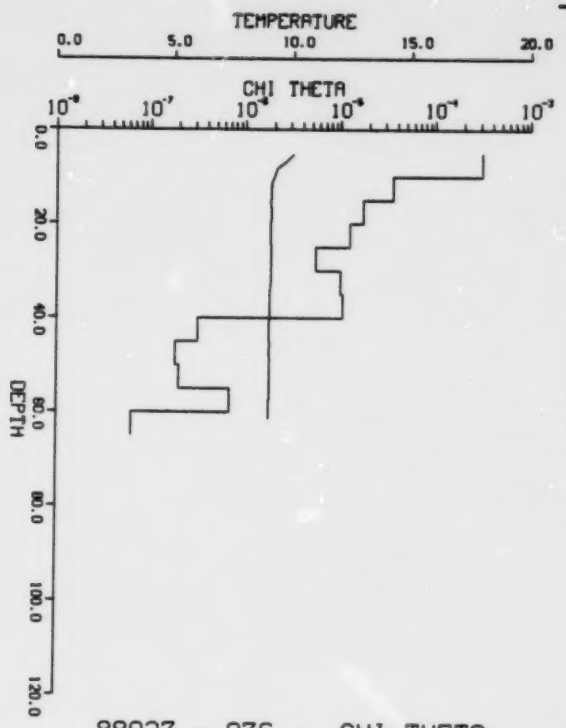
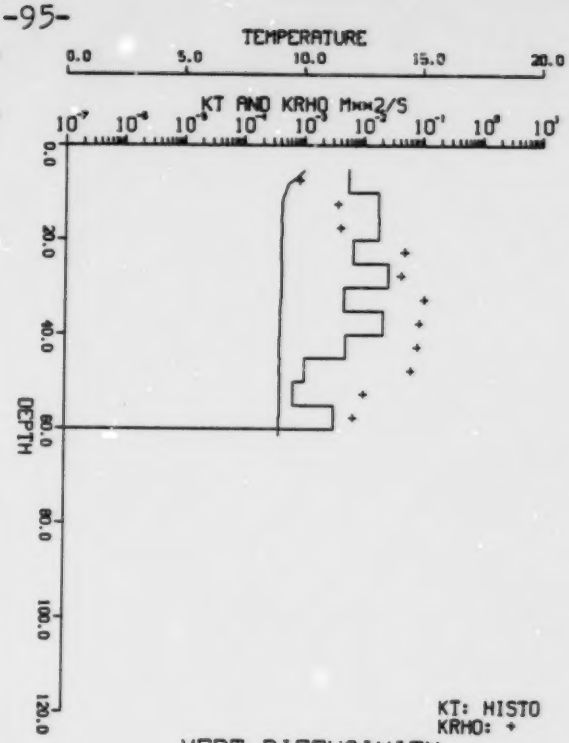


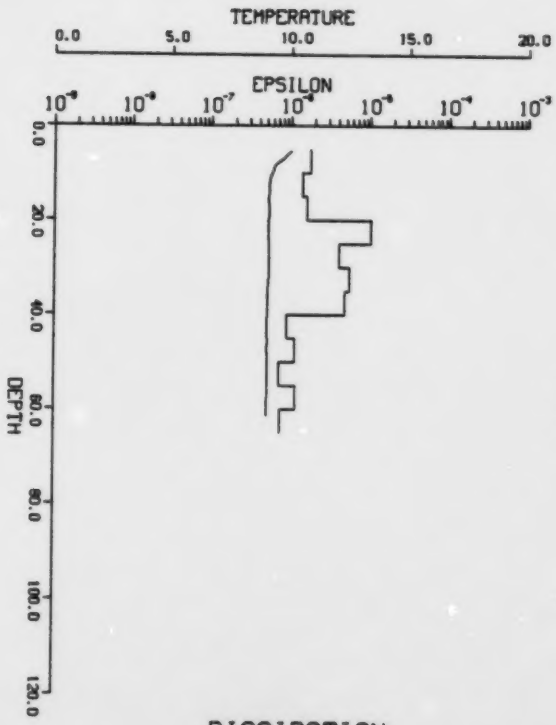

COX NUMBER H




88023 - 036 CHI-THETA




VERT DIFFUSIVITY

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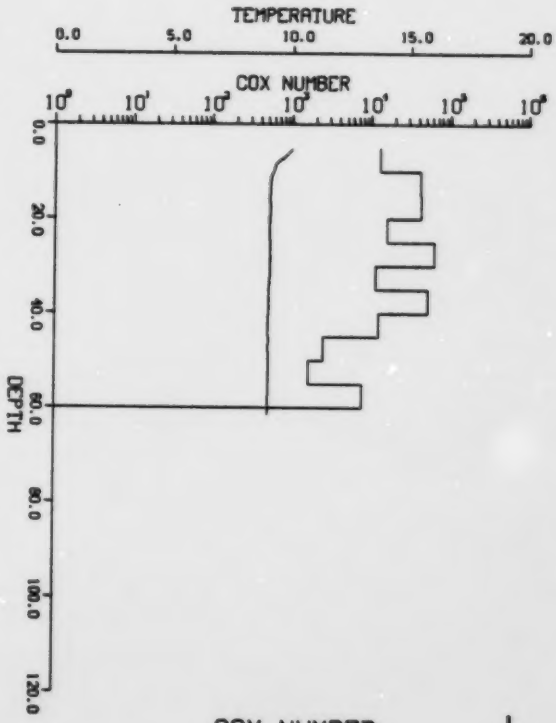
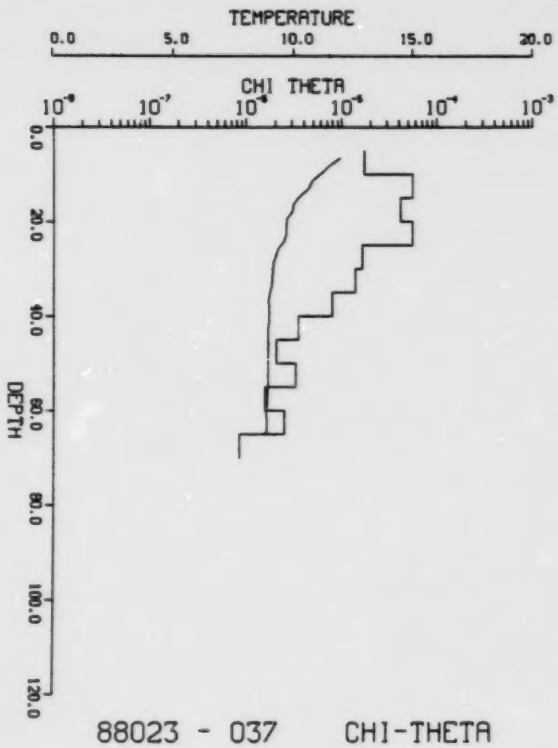
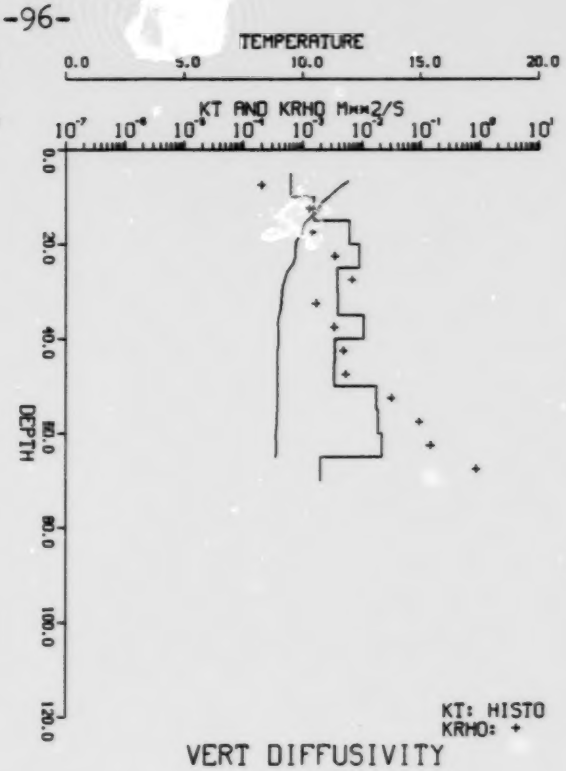



COX NUMBER




88023 - 037 CHI-THETA

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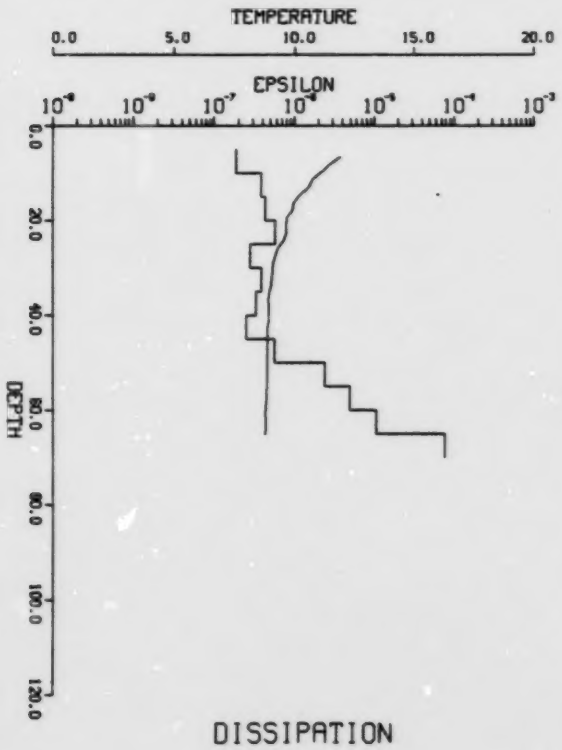


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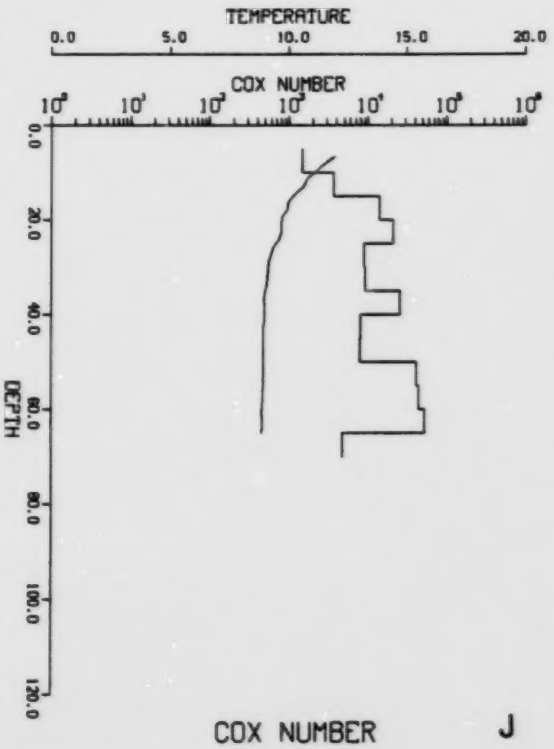


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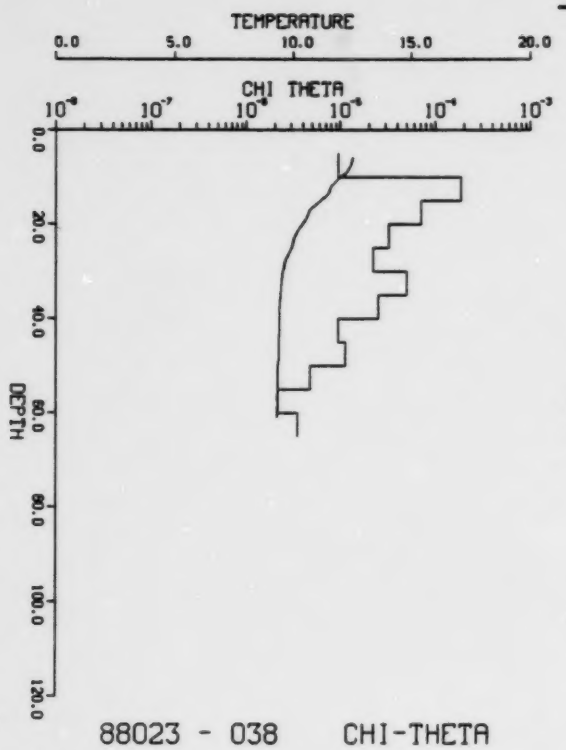
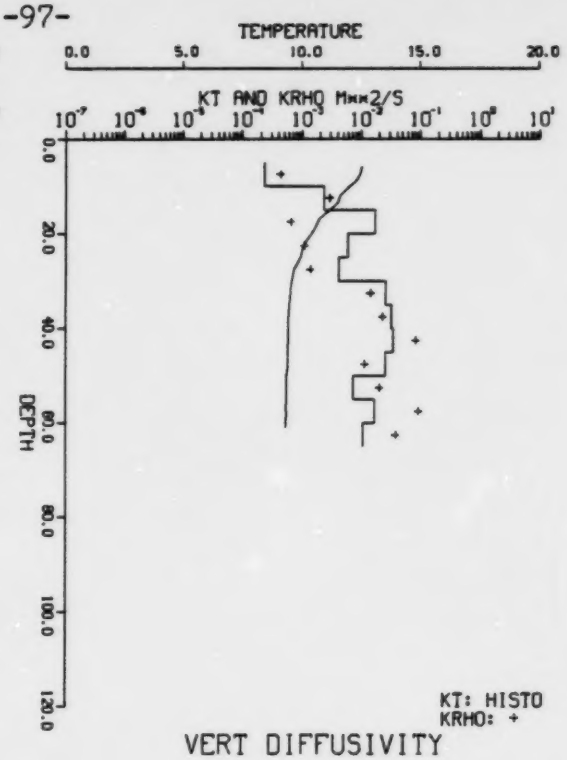



88023 - 038 CHI-THETA

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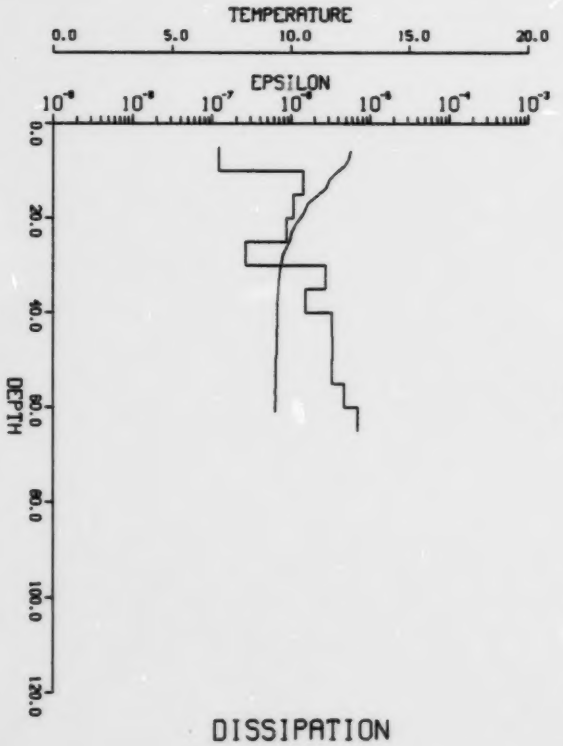


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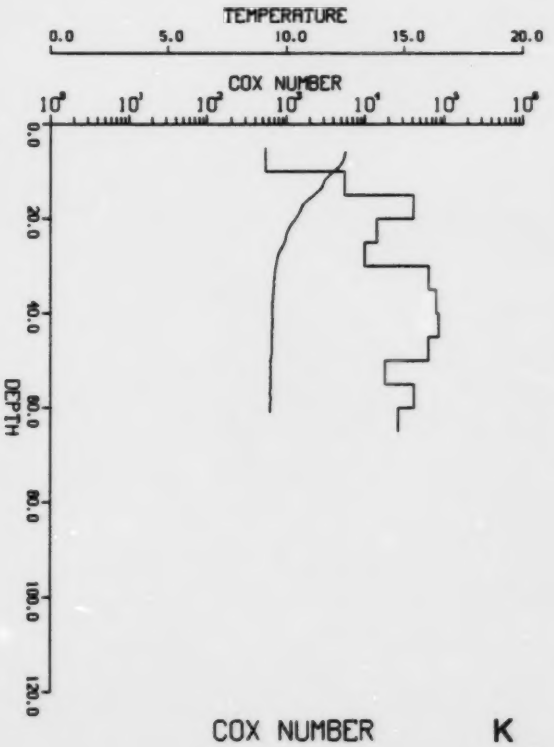


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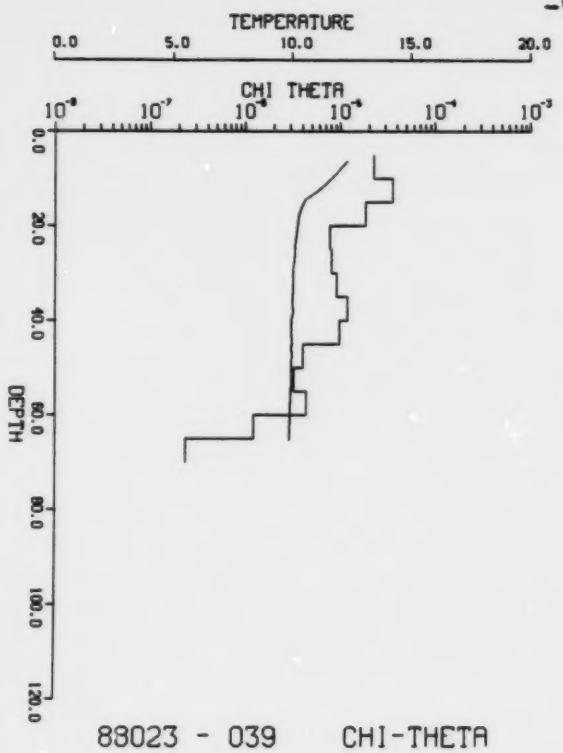
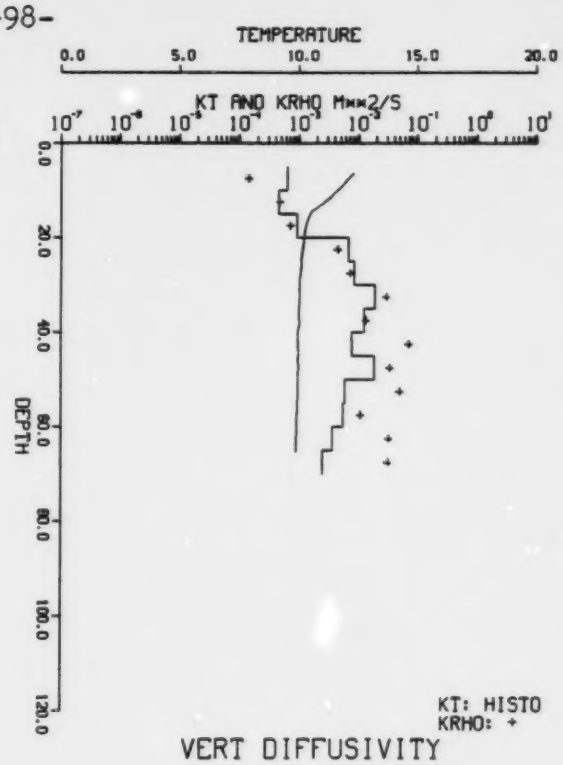



88023 - 039 CHI-THETA

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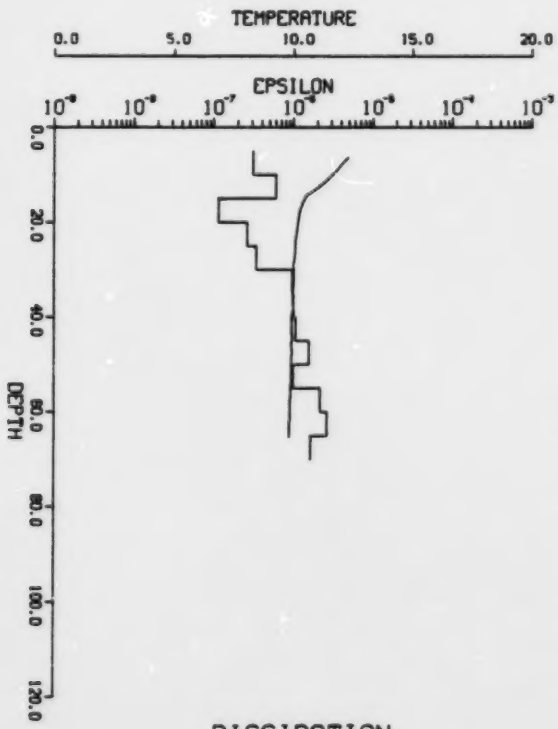


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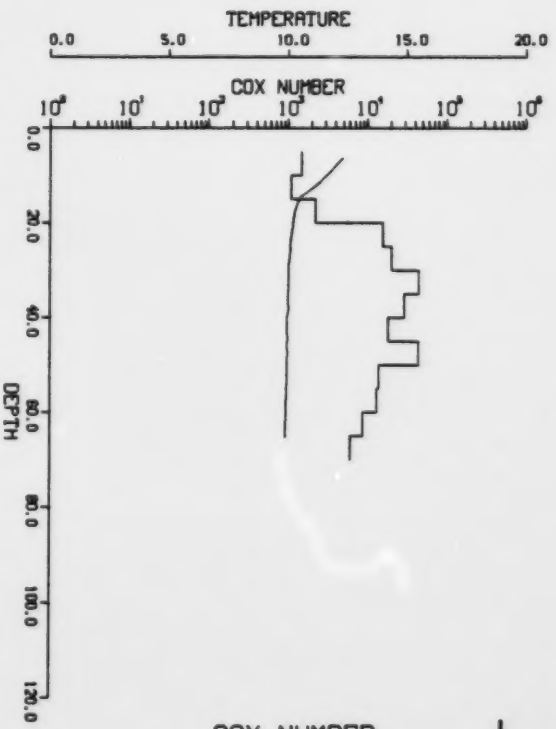


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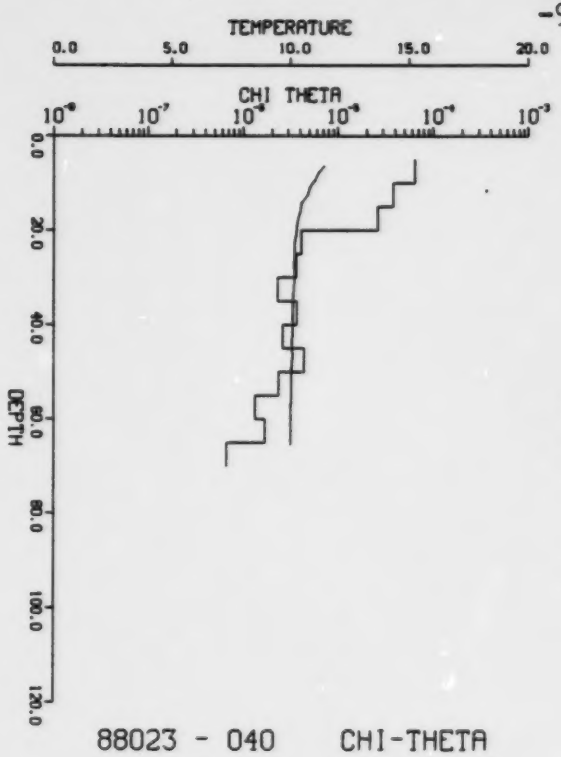
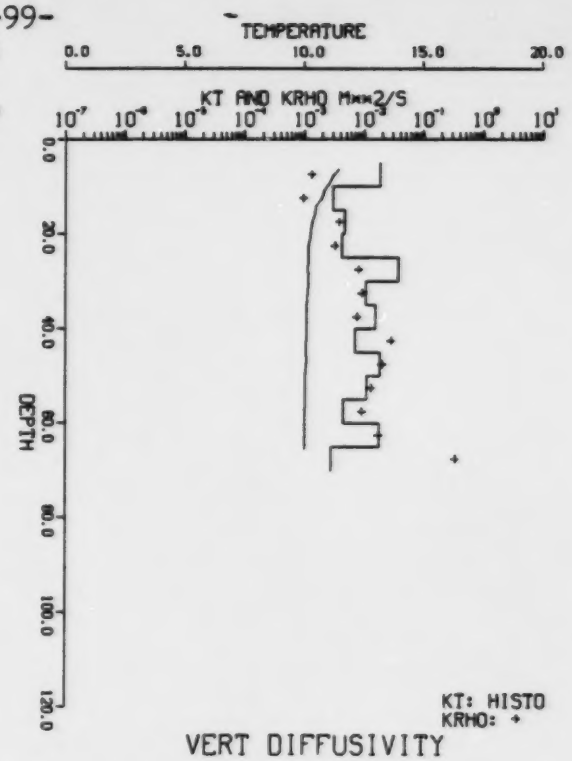



88023 - 040 CHI-THETA

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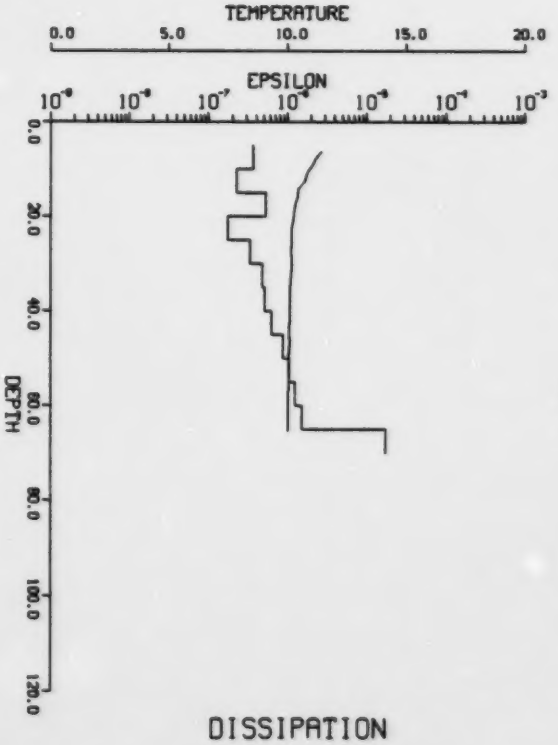


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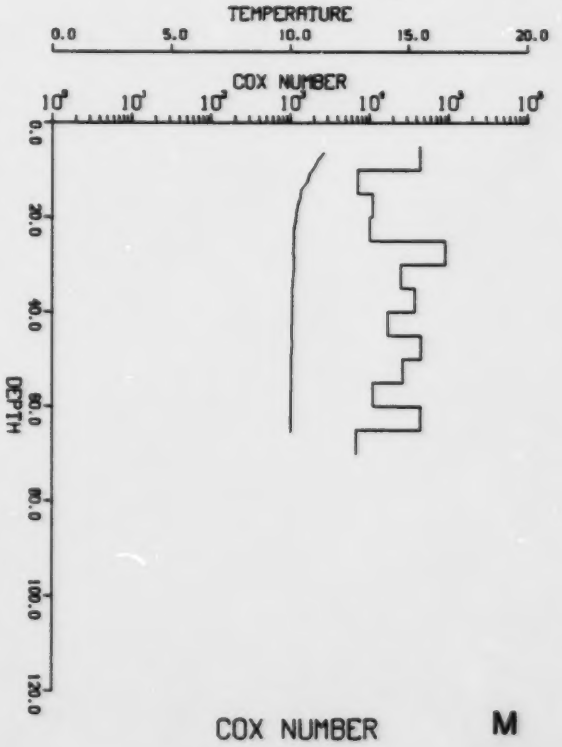


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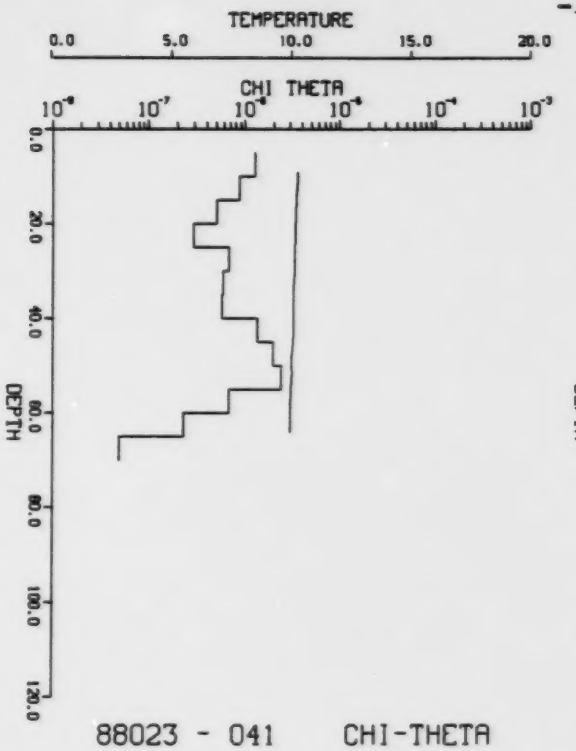


88023 - 041 CHI-THETA

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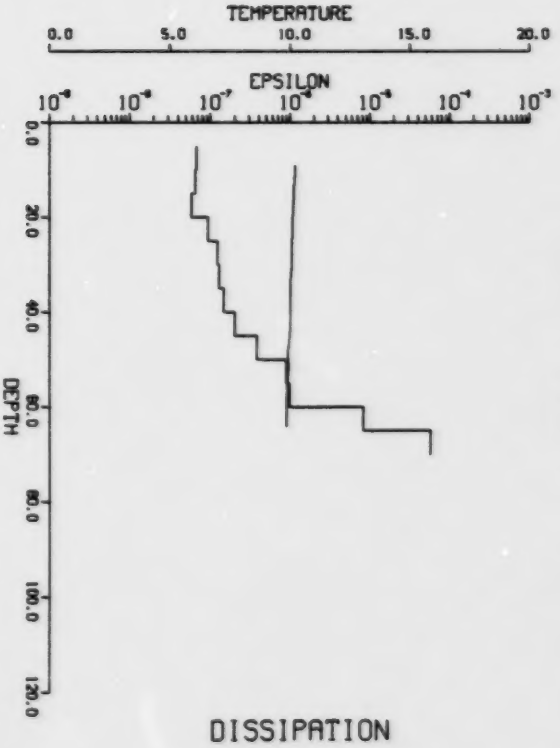


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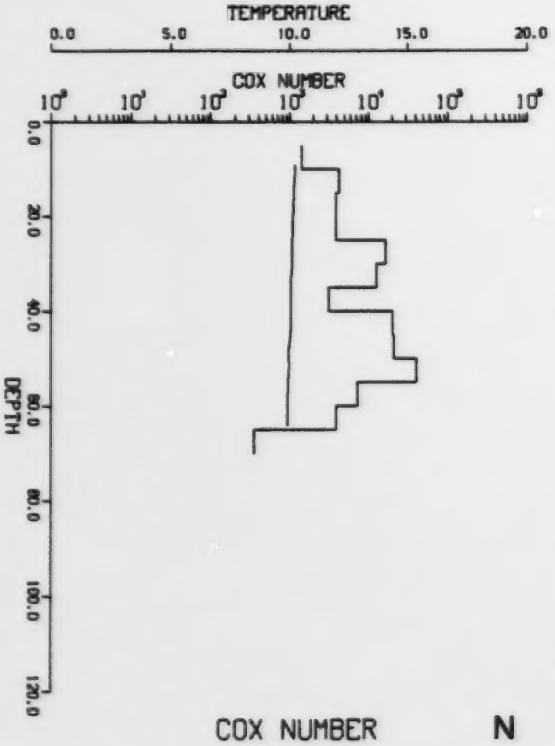



COX NUMBER N

# SITE 4A23

41°53.70N, 66°46.91W

TABLE 6: COMBINED CURRENT AND DISSIPATION

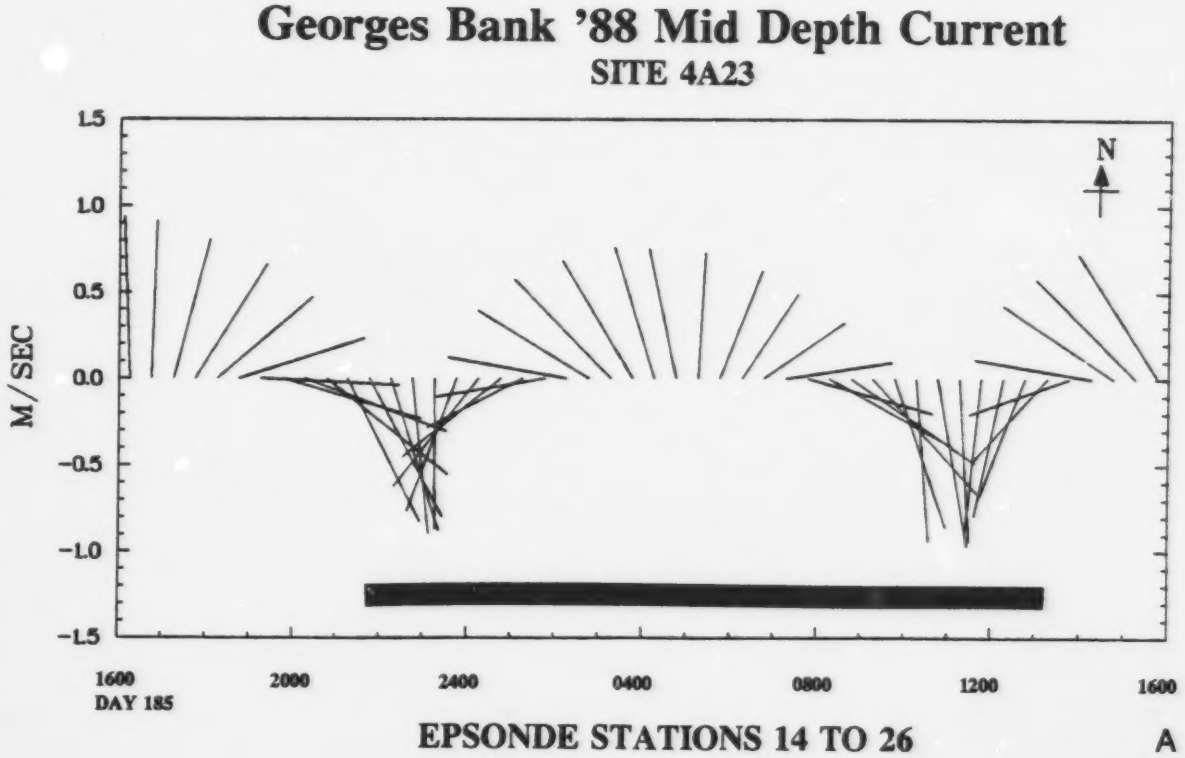
| Station | TimeEPS | Depth | Drops | Current | IntEPS | ErrEPS |
|---|---|---|---|---|---|---|
| E14 | 185.9146 | 60.45 | 8 | 1.015 | 0.1847 | 0.0312 |
| E15 | 185.9639 | 59.30 | 8 | 0.975 | 0.1455 | 0.0621 |
| E16 | 186.0128 | 60.25 | 8 | 0.777 | 0.0947 | 0.0103 |
| E17 | 186.0576 | 55.50 | 6 | 0.633 | 0.1568 | 0.0816 |
| E18 | 186.1962 | 61.50 | 8 | 0.809 | 0.1437 | 0.0305 |
| E19 | 186.2438 | 61.50 | 8 | 0.661 | 0.1197 | 0.0272 |
| E20 | 186.2910 | 60.80 | 8 | 0.589 | 0.0482 | 0.0044 |
| E21 | 186.3351 | 61.50 | 8 | 0.785 | 0.0480 | 0.0088 |
| E22 | 186.3764 | 59.95 | 8 | 0.961 | 0.1561 | 0.0587 |
| E23 | 186.4163 | 59.90 | 8 | 1.031 | 0.1592 | 0.0199 |
| E24 | 186.4622 | 58.40 | 6 | 1.021 | 0.3911 | 0.1061 |
| E25 | 186.5028 | 59.65 | 8 | 0.898 | 0.2952 | 0.0615 |
| E26 | 186.5441 | 59.00 | 8 | 0.710 | 0.1155 | 0.0182 |

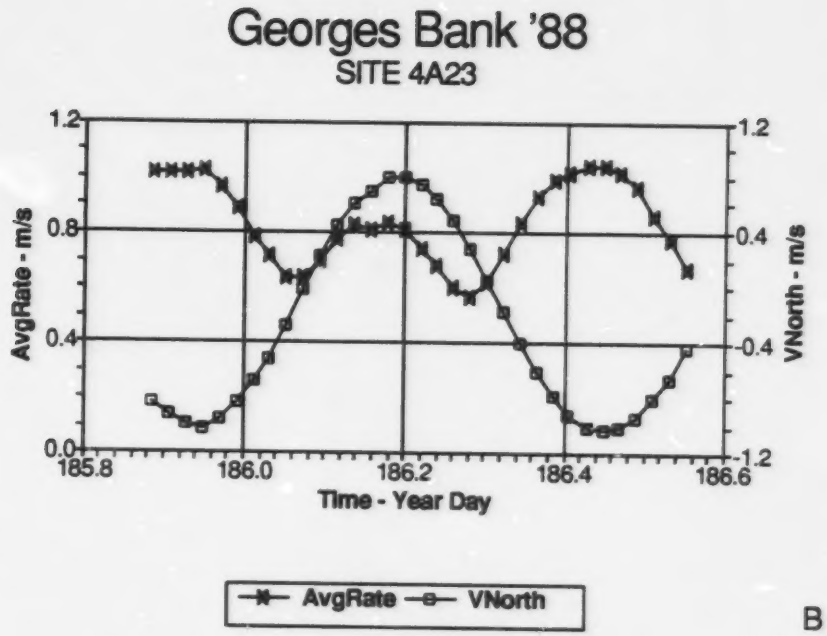
FIGURE 14:

A. Current vector plot for the RCM at 34m depth at site 4 overlapping the EPSONDE anchor station 4A during cruise 88023 (4A23). This anchor station includes EPSONDE stations 14 to 26.

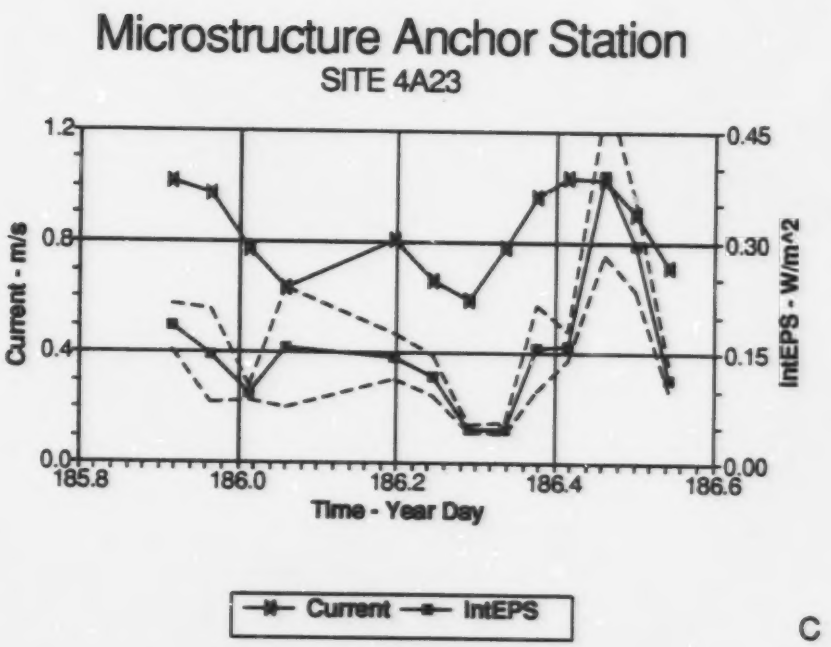
B. The magnitude and the northward component of the vertically averaged composite RCM and Ametek DCP current at half hourly intervals for site 4 coincident with EPSONDE anchor station 4A23.

C. The magnitude of the vertically averaged composite current interpolated to the mean EPSONDE station time and the integrated dissipation, IntEPS, for each EPSONDE station during anchor station 4A23. Error limits are indicated for IntEPS.




Georges Bank '88
SITE 4A23
AvgRate - m/s
VNorth - m/s
Time - Year Day
AvgRate
VNorth

B

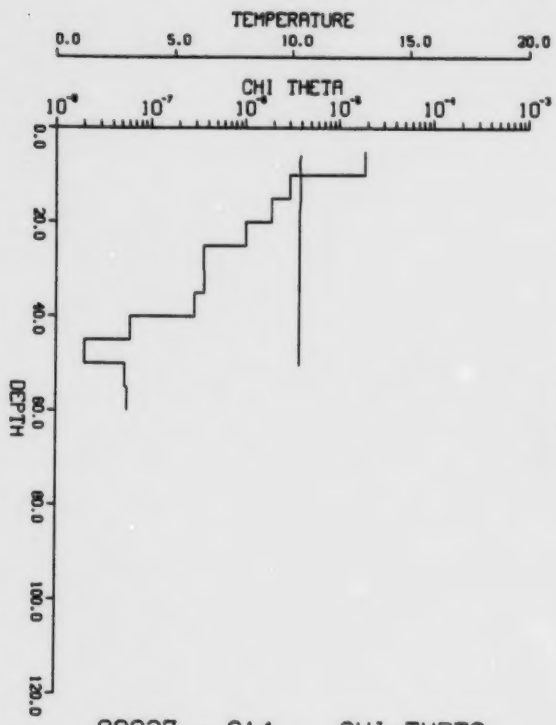

Microstructure Anchor Station
SITE 4A23
Current - m/s
IntEPS - W/m^2
Time - Year Day
Current
IntEPS

C

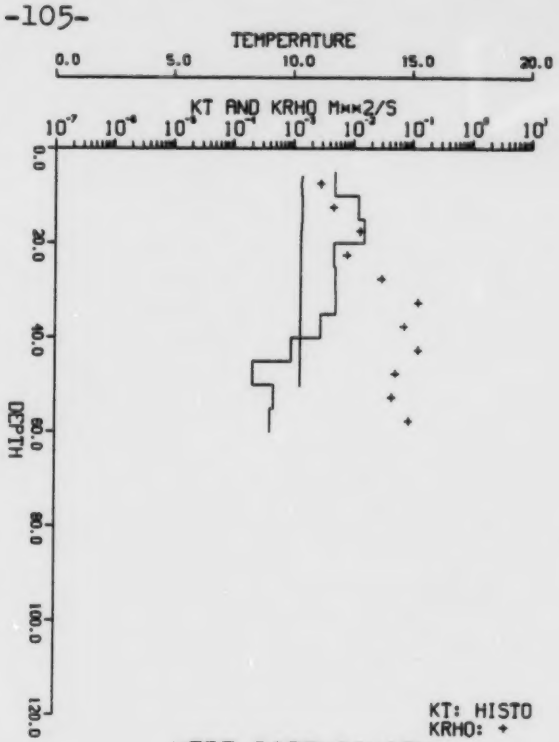
FIGURE 15: Profiles of microstructure quantities for stations 14 to 26 for anchor station 4A23.
- Each page contains a profile of a microstructure quantity averaged over 5 m vertical bins overlaid on a profile of temperature.
- The upper left panel is Chi-Theta, the dissipation of temperature variance.
- The upper right panel contains profiles of vertical diffusivity KT (for temperature) and KRHO for density.
- The lower left panel contains a profile of dissipation, EPSILON.
- The lower right panel shows the profile for Cox number.

The stations are shown in the following order:

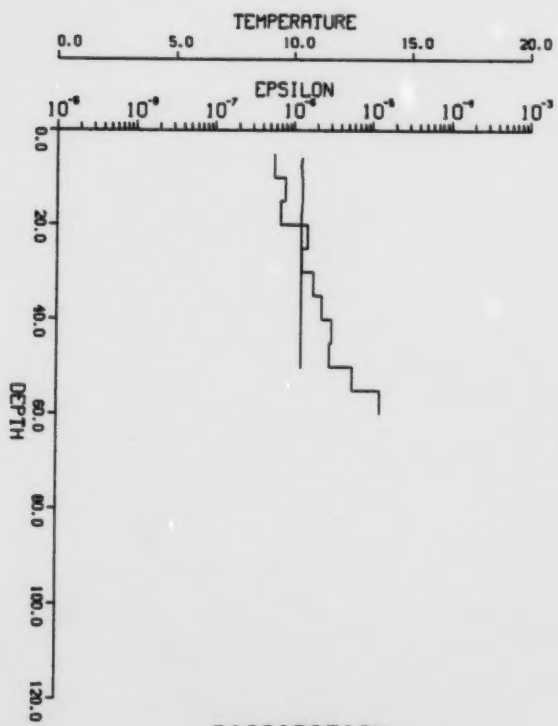
A. Station 14
B. Station 15
C. Station 16
D. Station 17
E. Station 18
F. Station 19
G. Station 20
H. Station 21
I. Station 22
J. Station 23
K. Station 24
L. Station 25
M. Station 26




88023 - 014 CHI-THETA

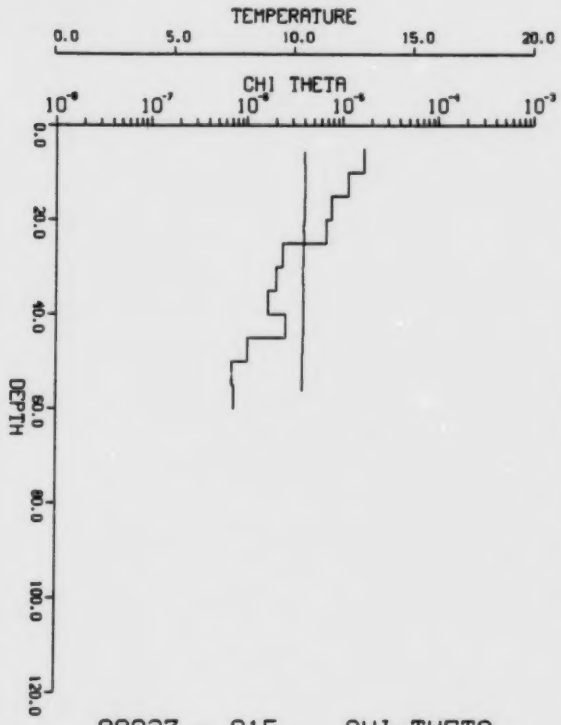



VERT DIFFUSIVITY

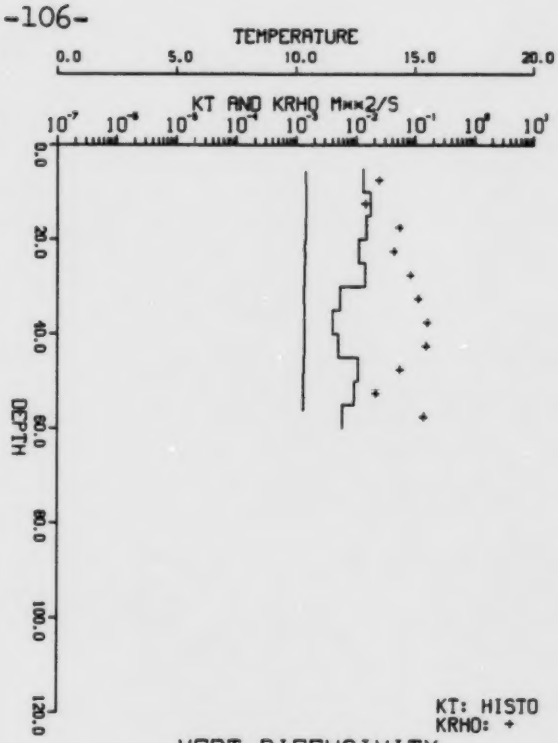



DISSIPATION

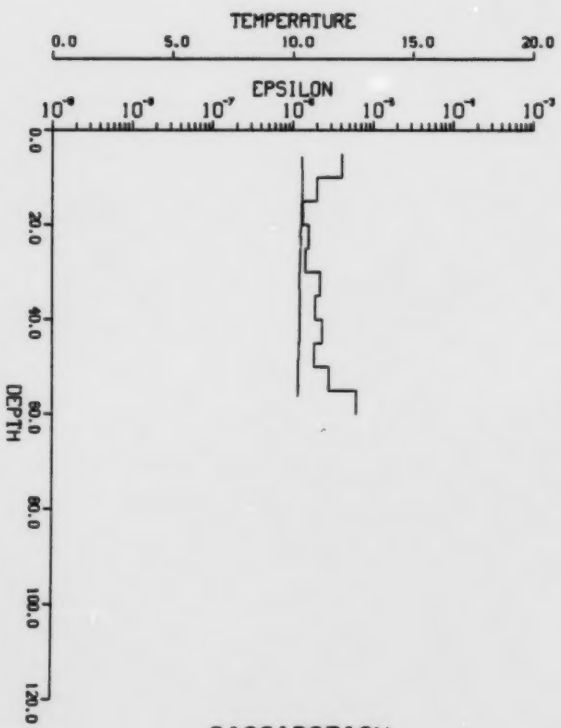
COX NUMBER A




88023 - 015 CHI-THETA




VERT DIFFUSIVITY

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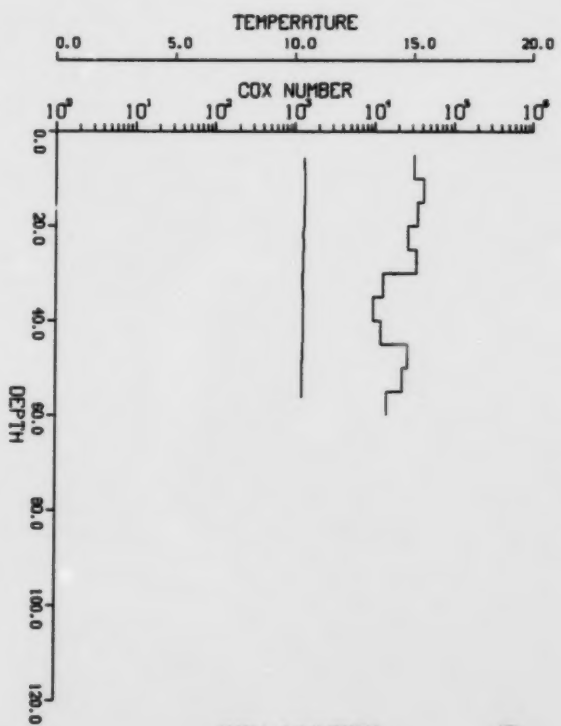


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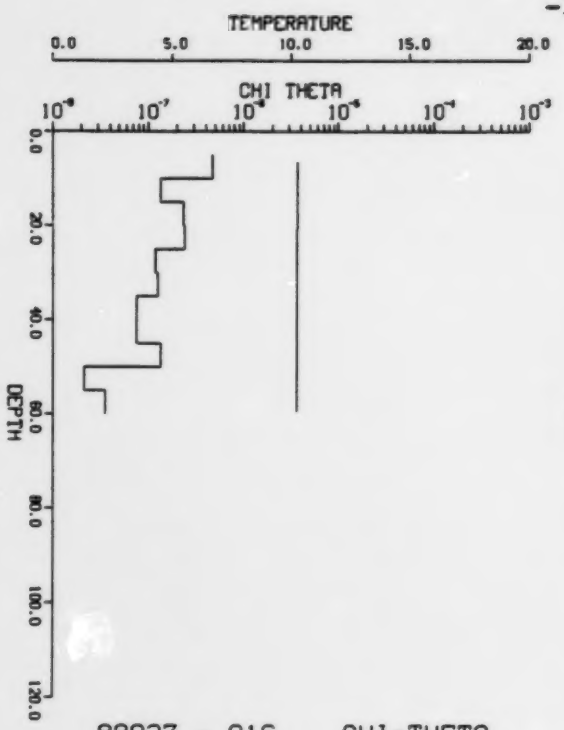
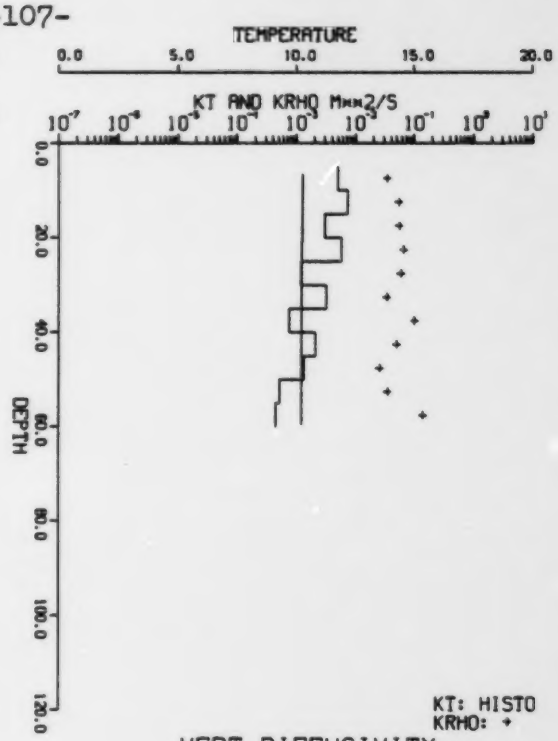



88023 - 016 CHI-THETA

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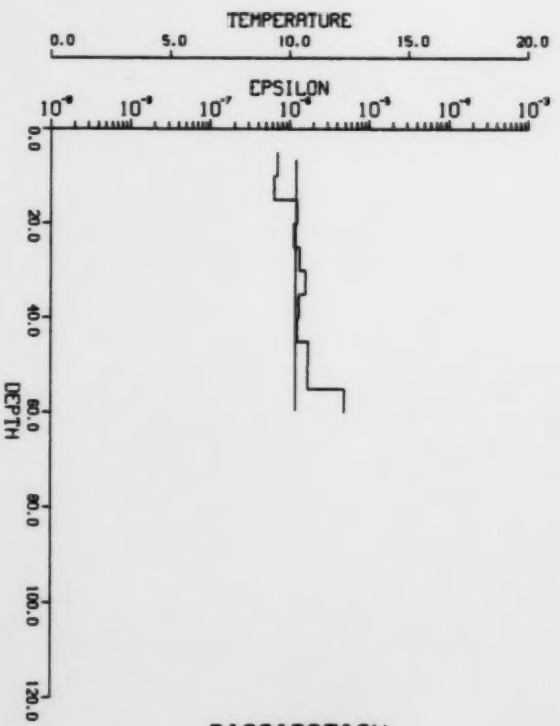


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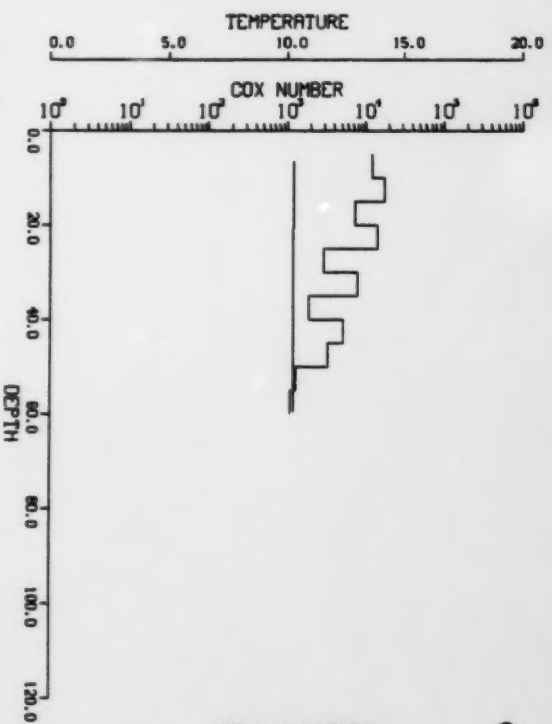


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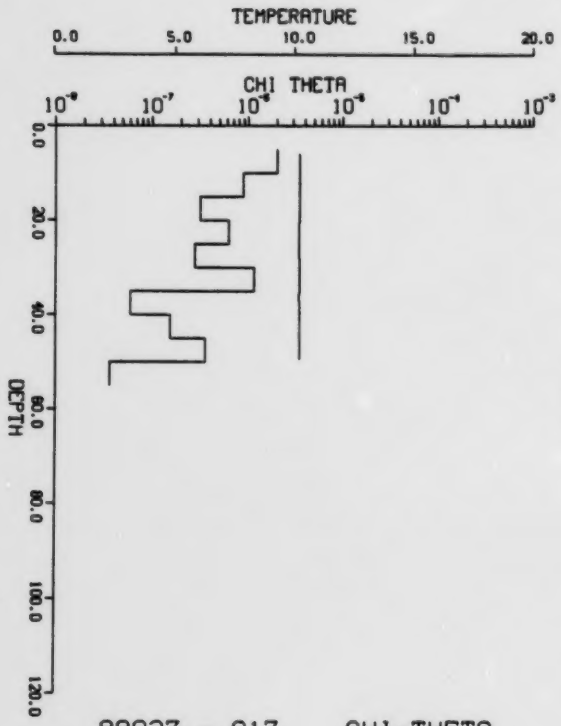
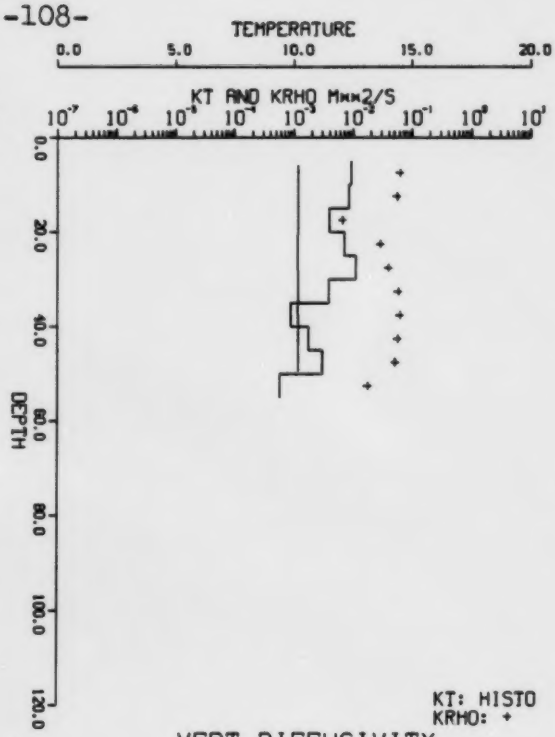



88023 - 017 CHI-THETA

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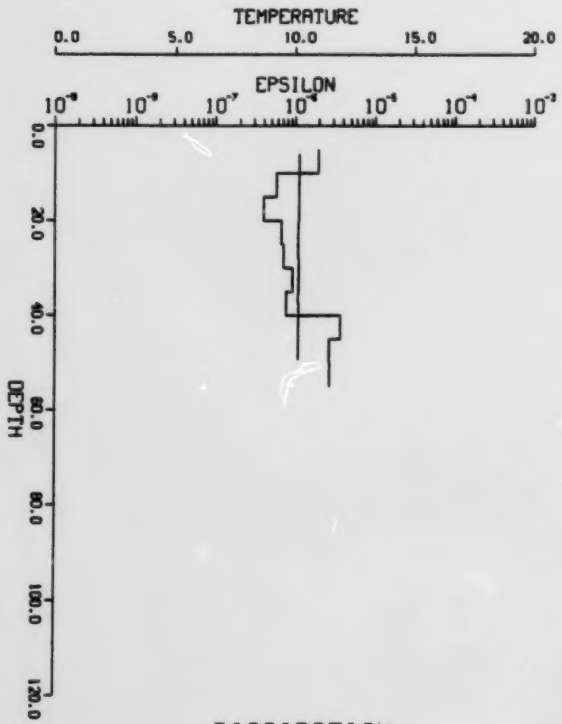


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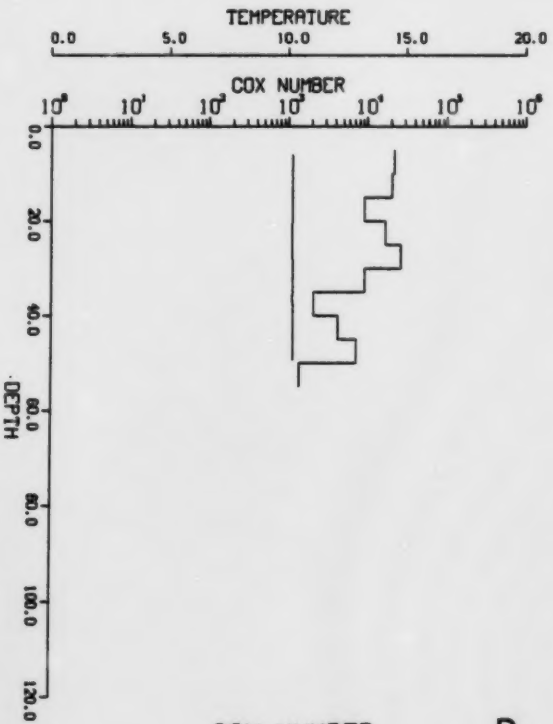


COX NUMBER

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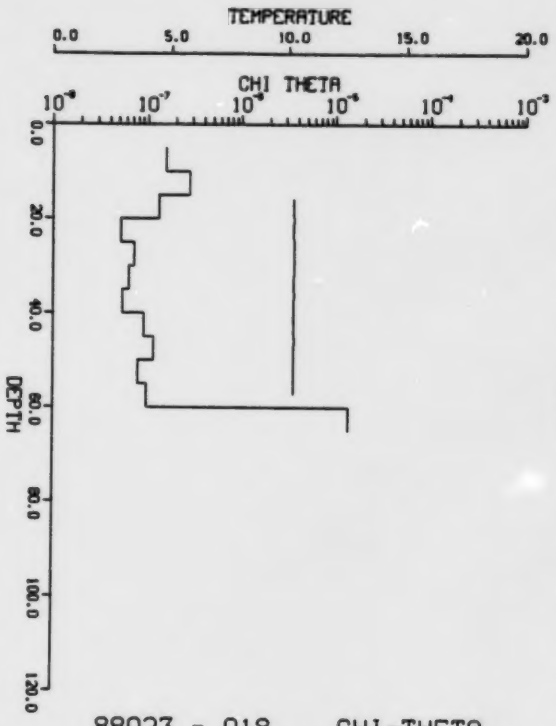
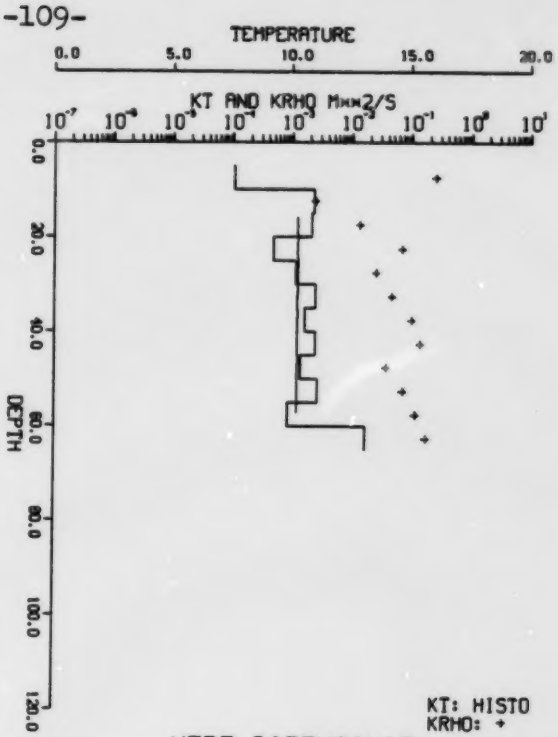



88023 - 018 CHI-THETA

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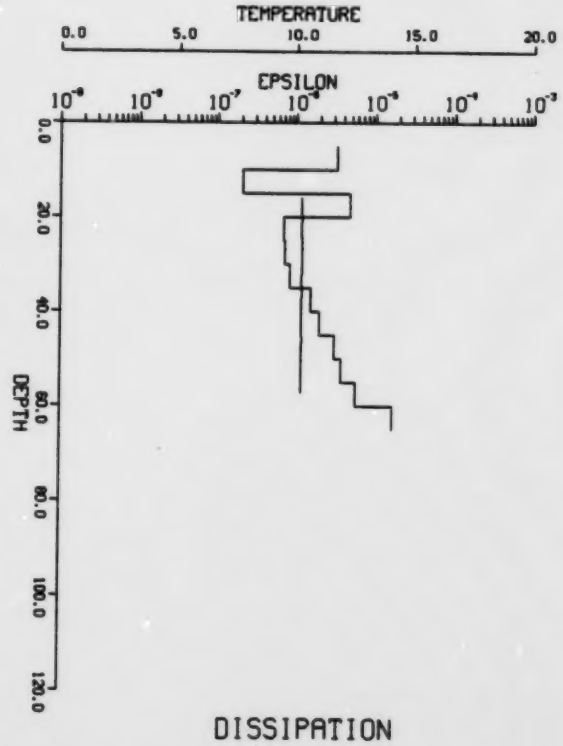


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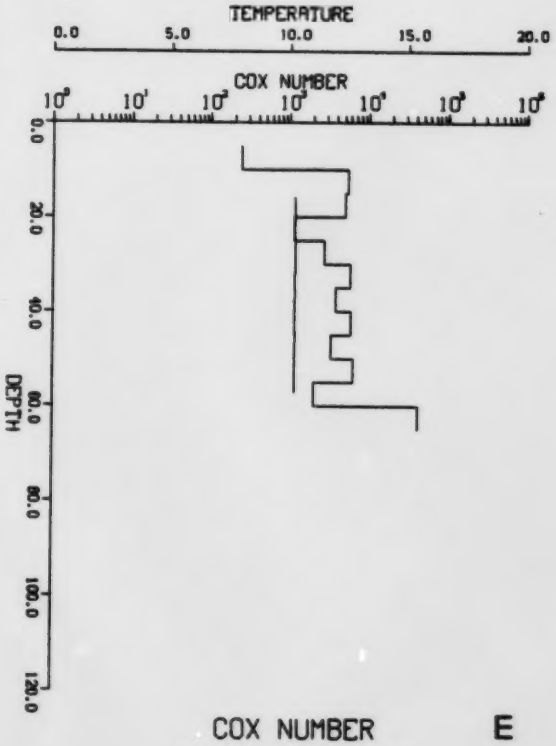


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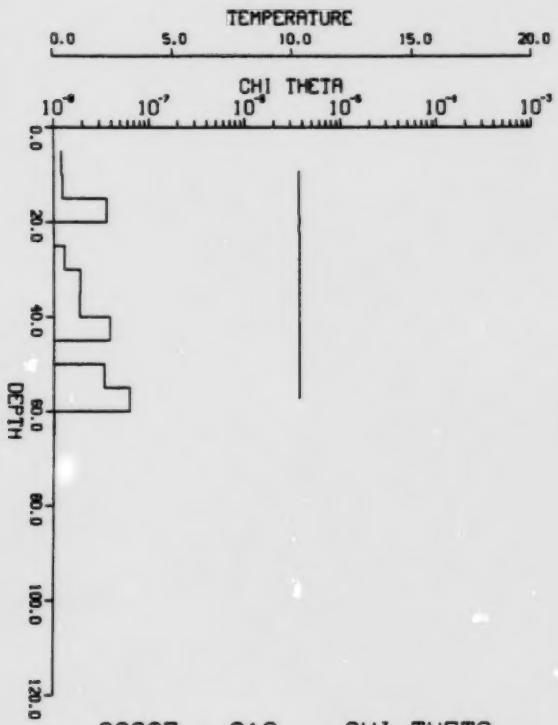
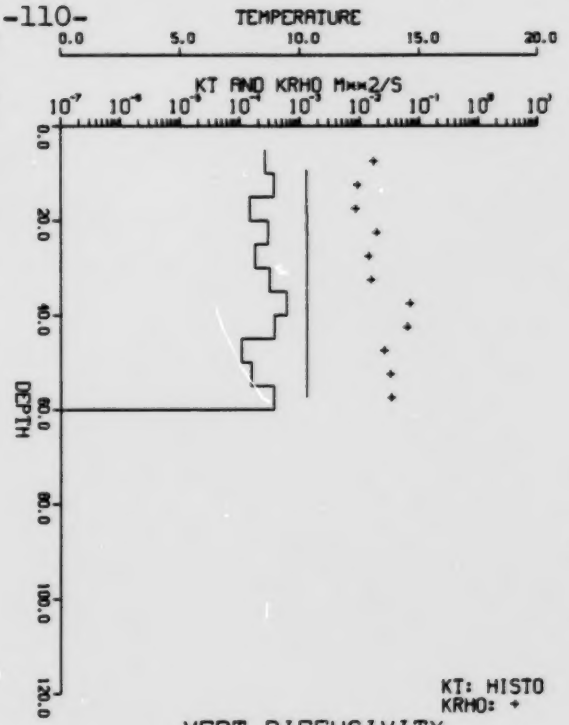



88023 - 019 CHI-THETA

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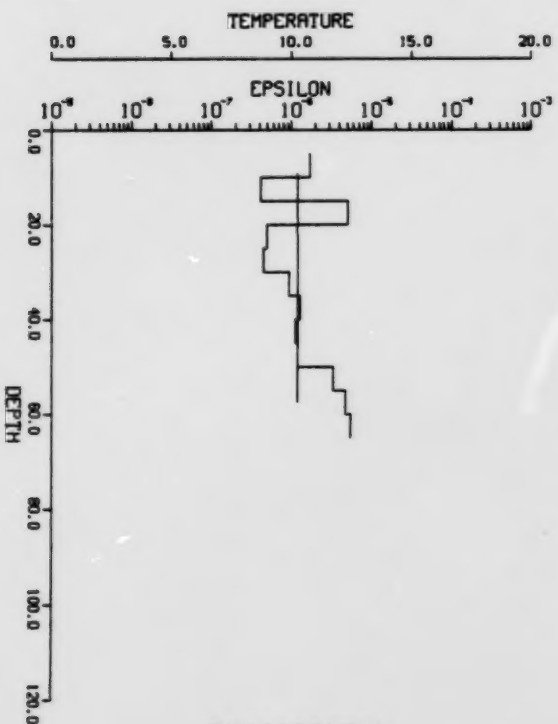


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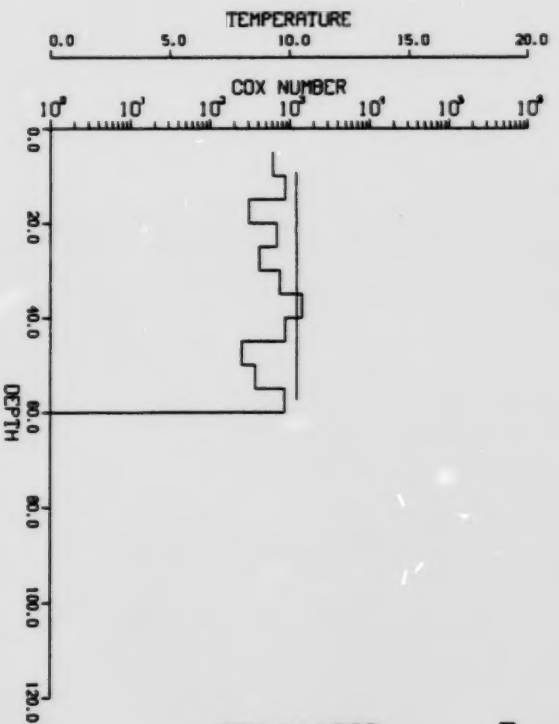


COX NUMBER

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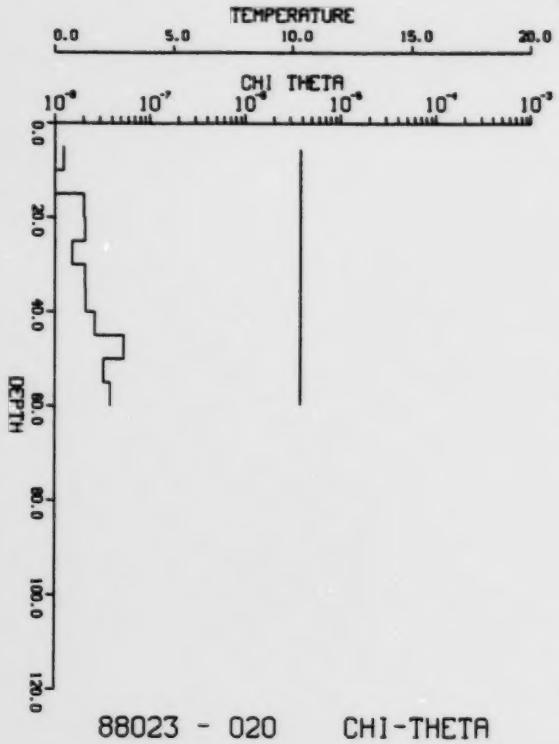
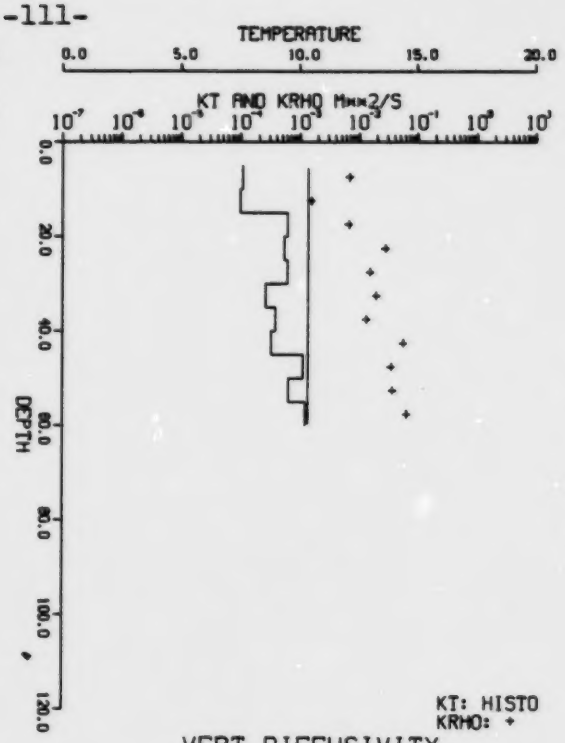
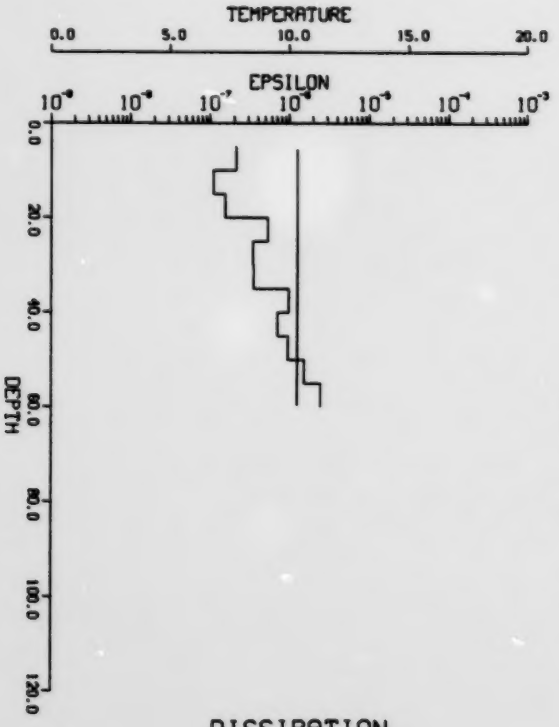



88023 - 020 CHI-THETA




VERT DIFFUSIVITY

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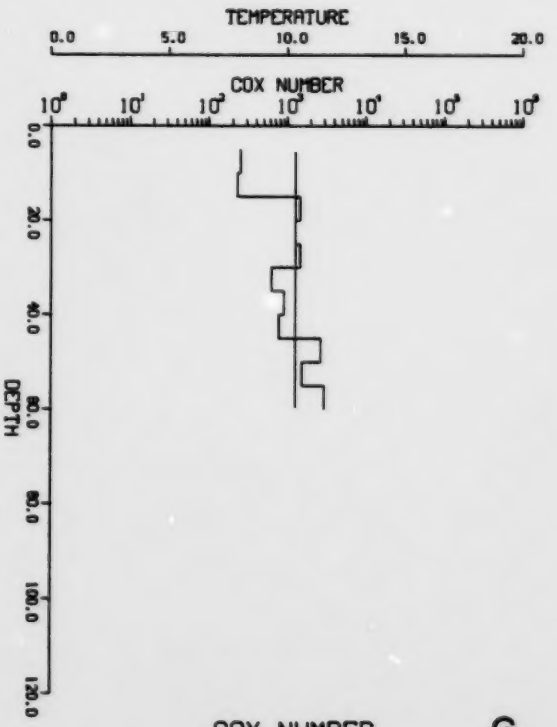


COX NUMBER

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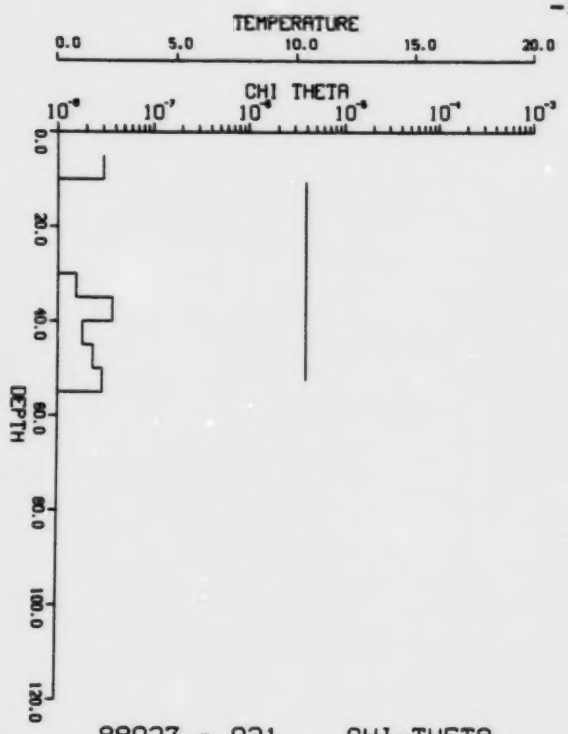
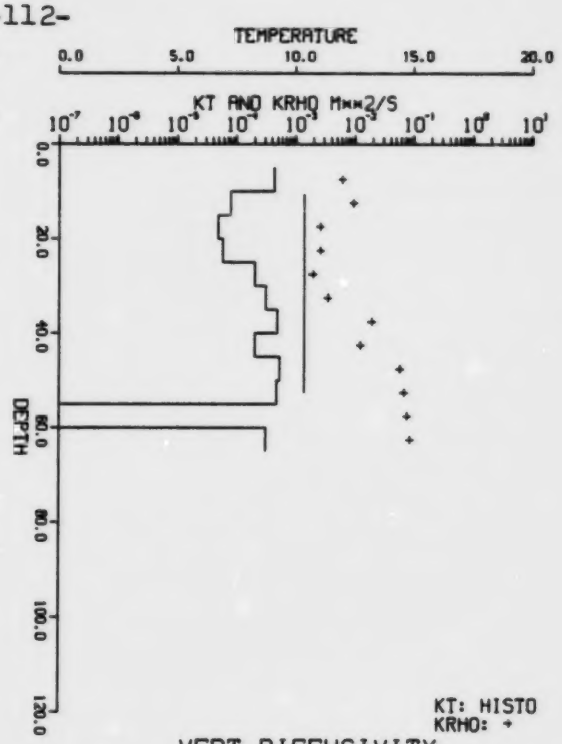



88023 - 021 CHI-THETA

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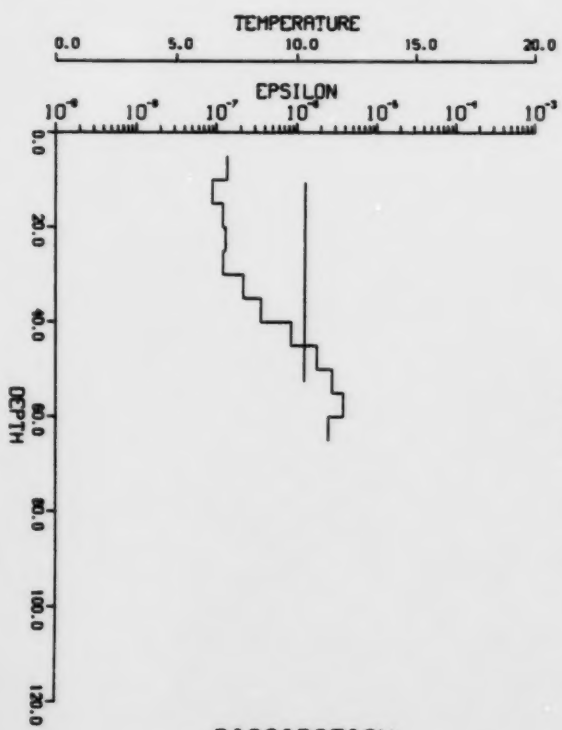


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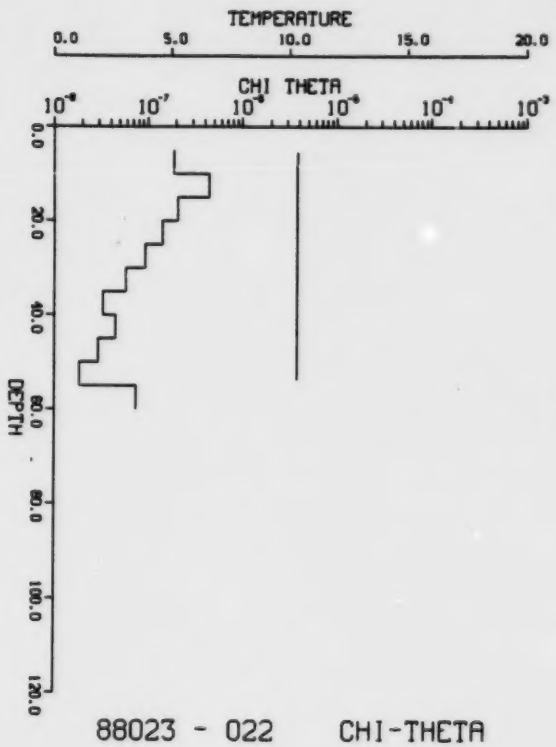
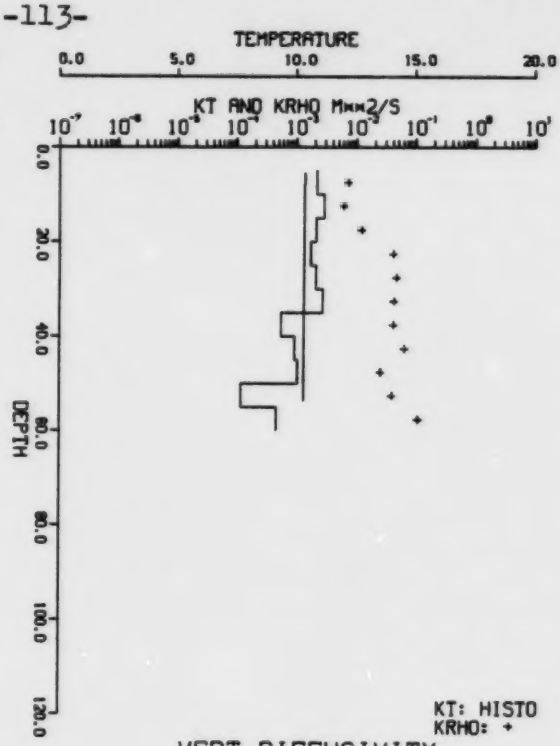



88023 - 022 CHI-THETA

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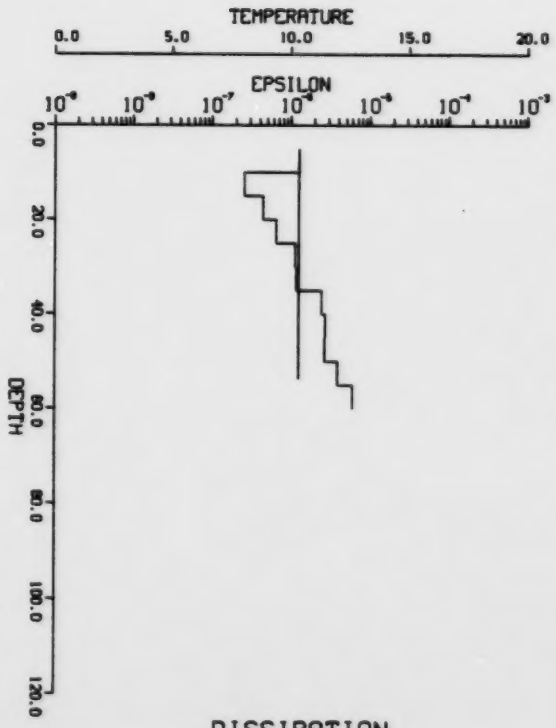


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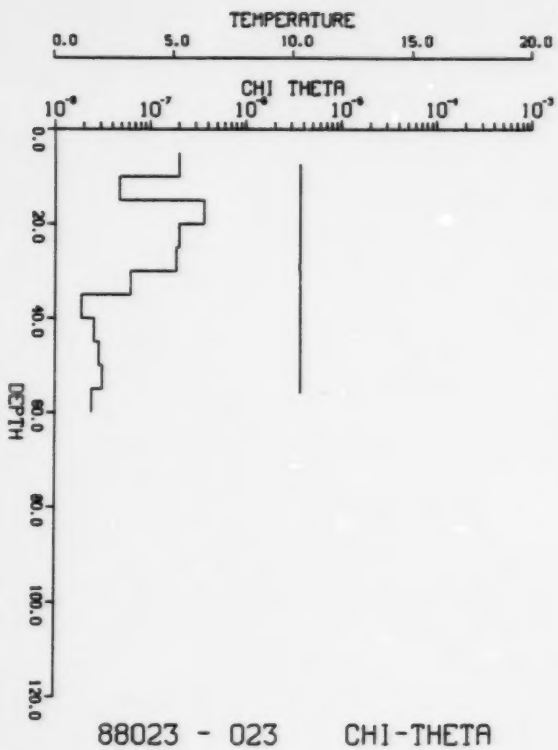
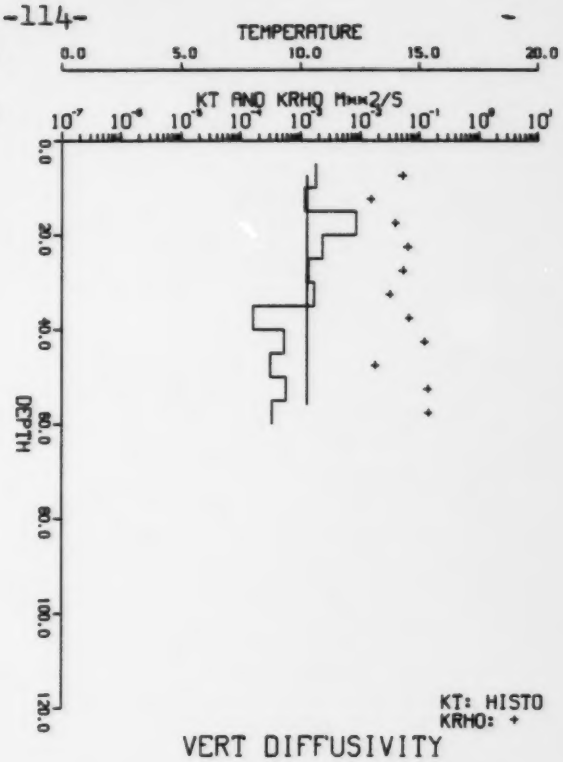



88023 - 023 CHI-THETA

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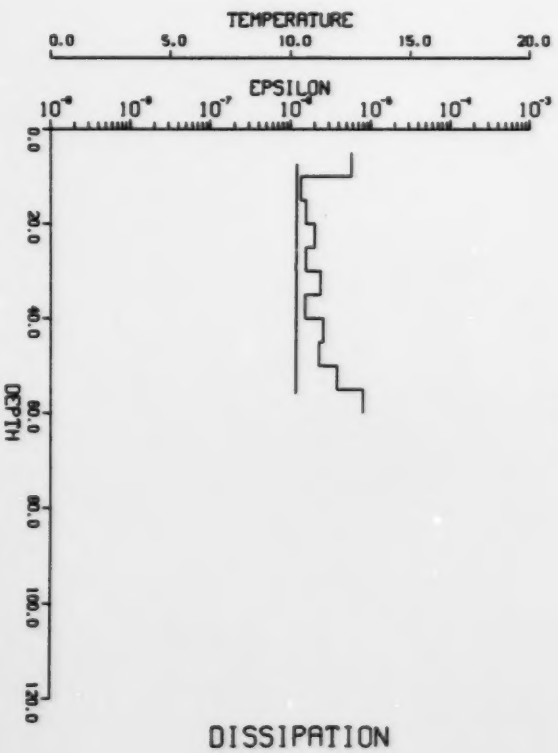


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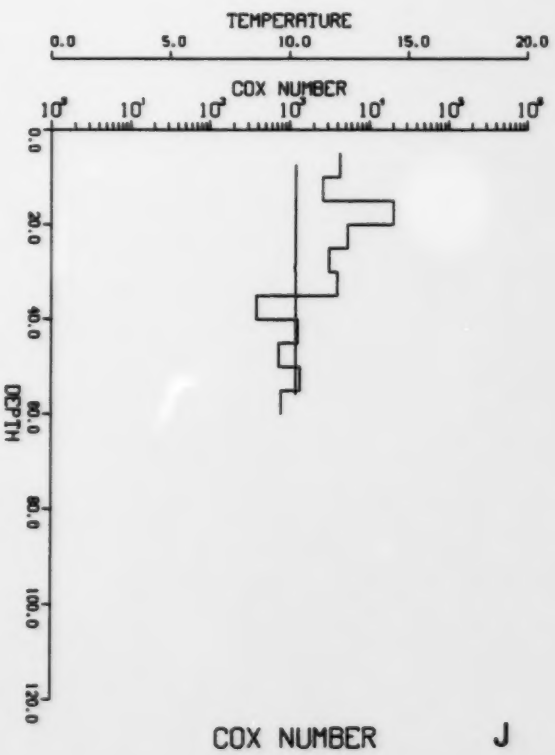


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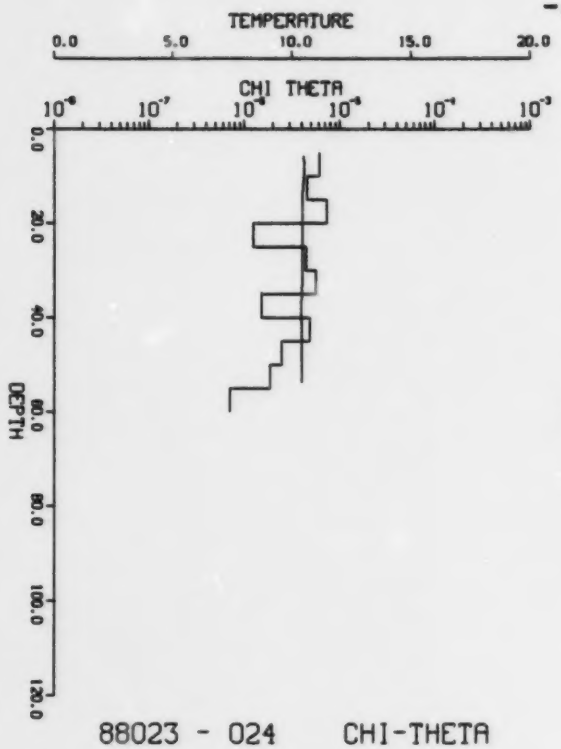
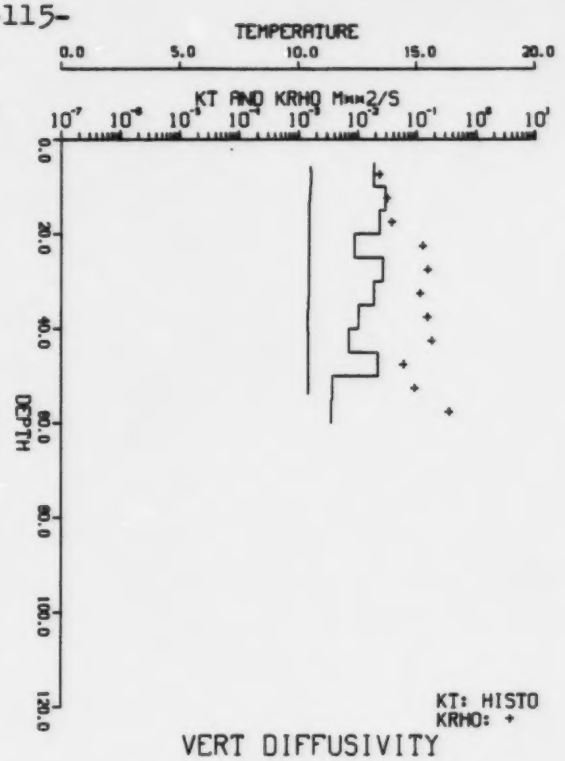



88023 - 024 CHI-THETA

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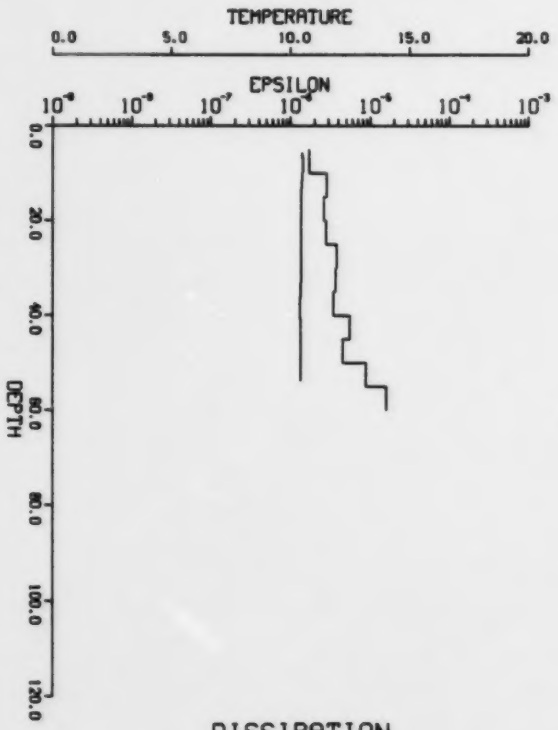


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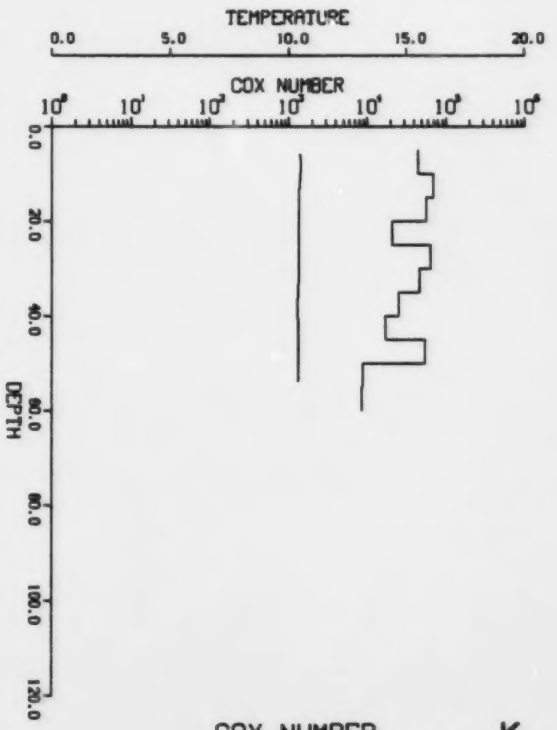
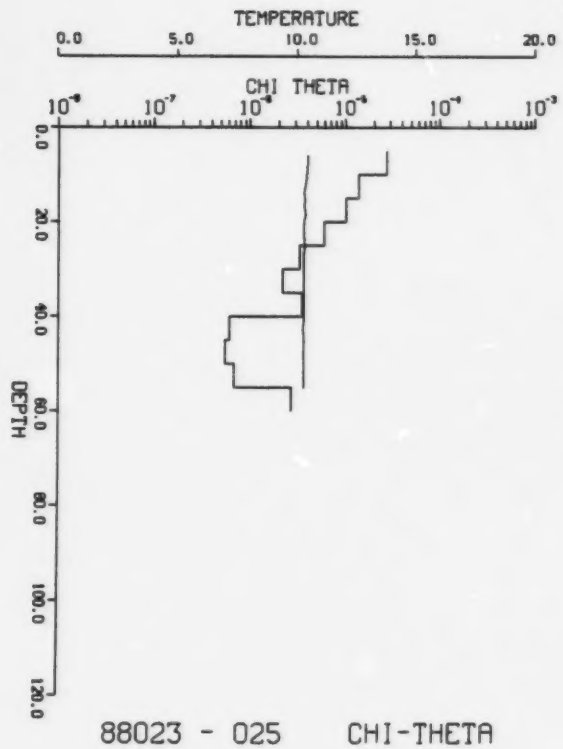
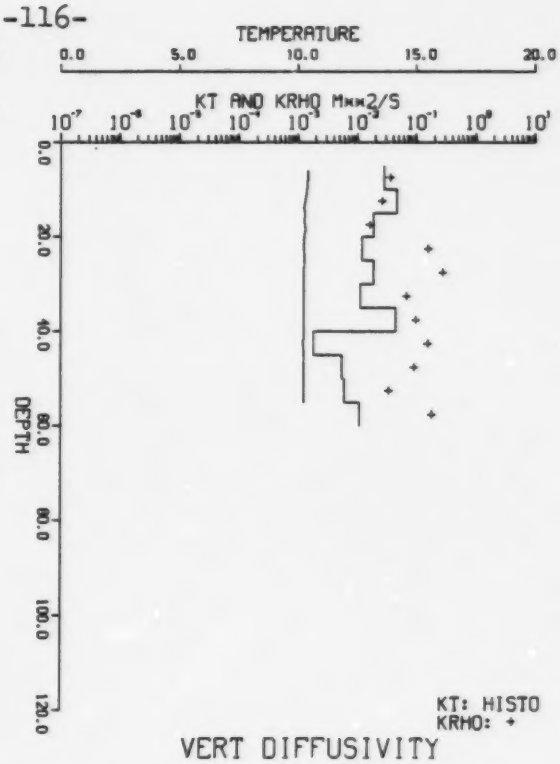



COX NUMBER K




88023 - 025 CHI-THETA

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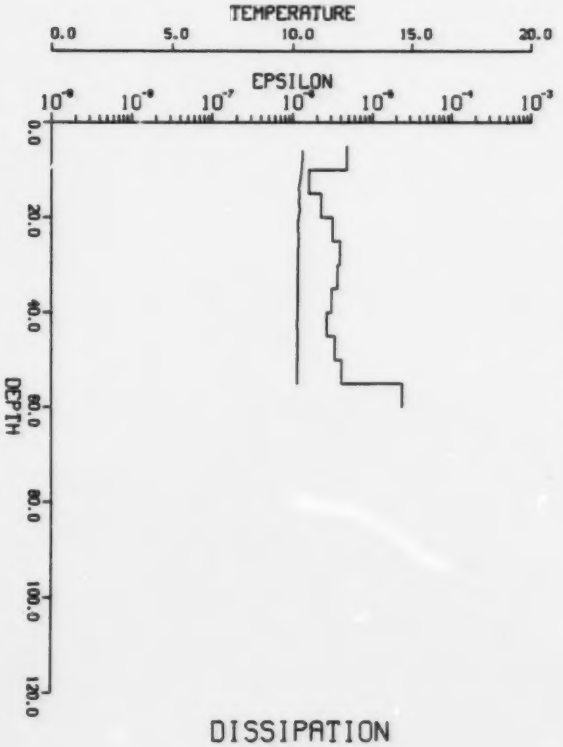


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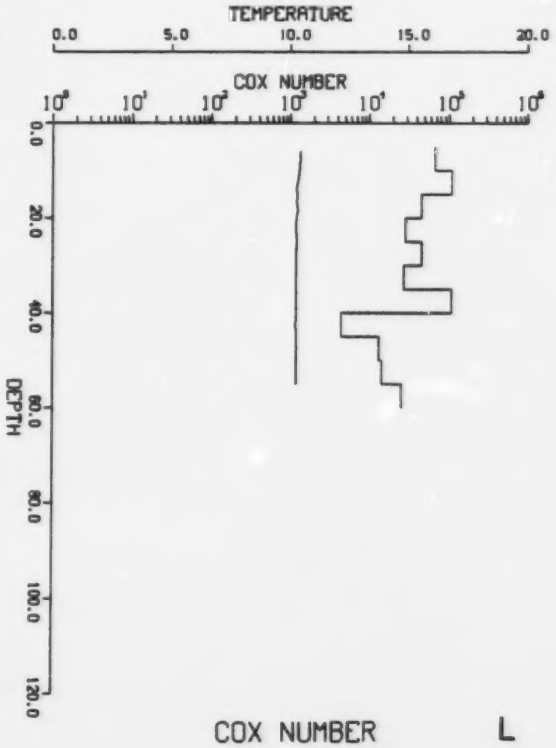
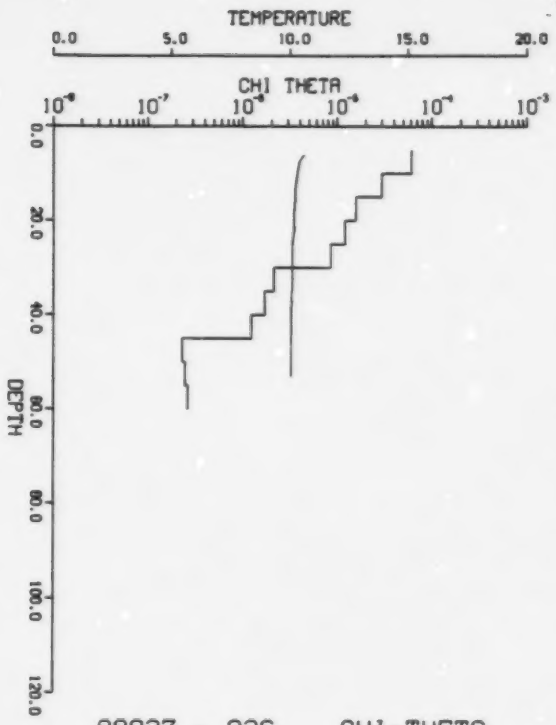
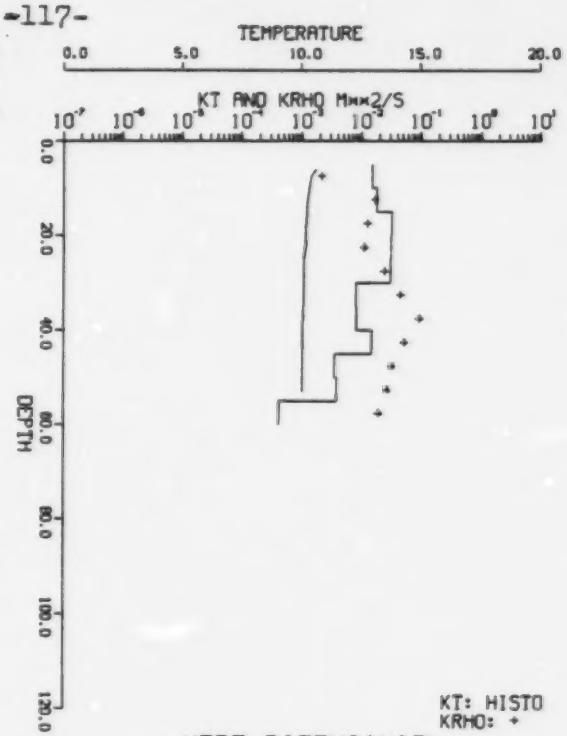



COX NUMBER L




88023 - 026 CHI-THETA

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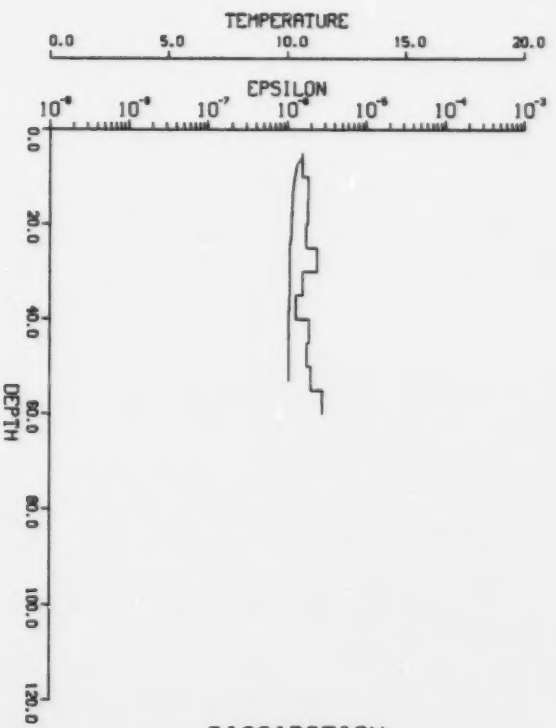
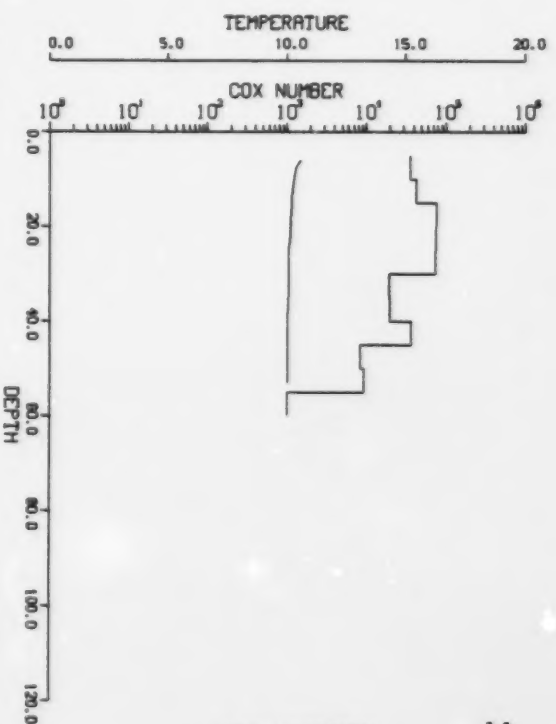



DISSIPATION




COX NUMBER M

# SITE 4B23

41°53.75N, 66°46.39W

TABLE 7: COMBINED CURRENT AND DISSIPATION

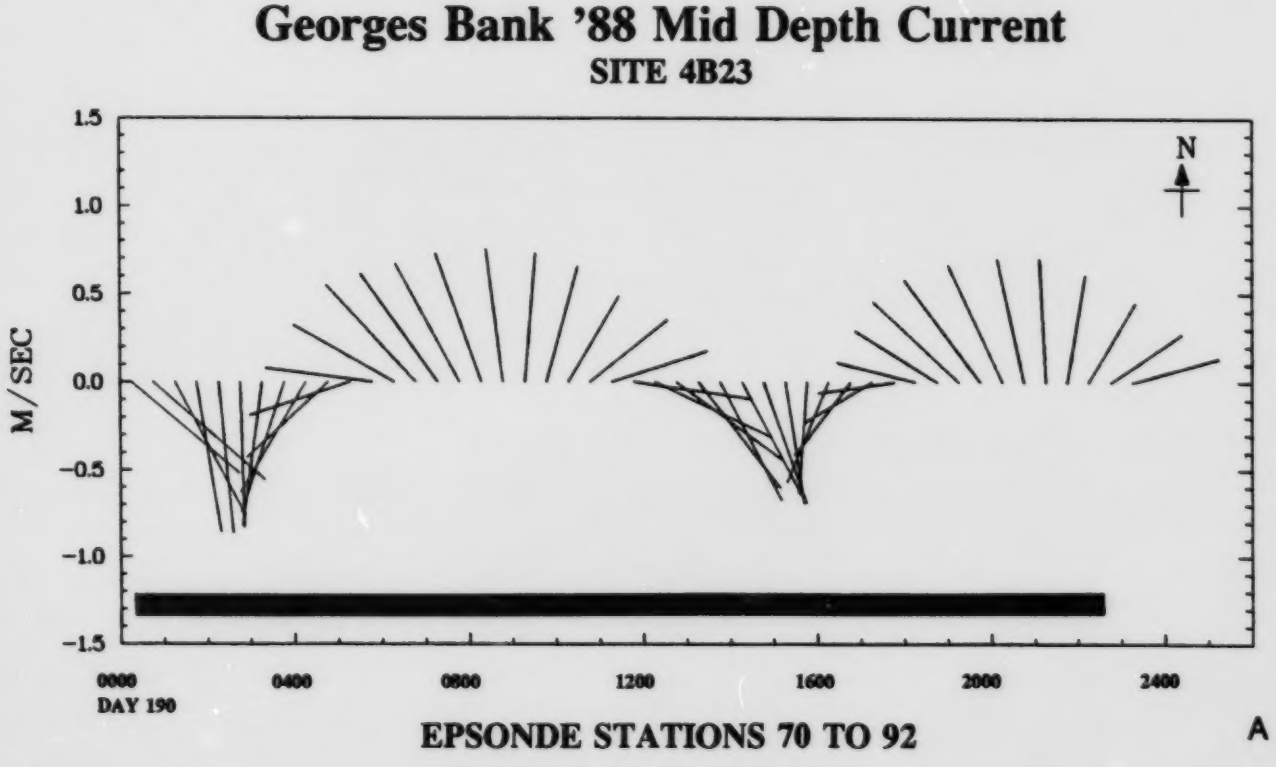
| Station | TimeEPS | Depth | Drops | Current | IntEPS | ErrEPS |
|---|---|---|---|---|---|---|
| E70 | 190.0205 | 61.40 | 8 | 0.911 | 0.1021 | 0.0182 |
| E71 | 190.0604 | 60.90 | 8 | 0.959 | 0.1259 | 0.0204 |
| E72 | 190.1038 | 60.20 | 8 | 0.958 | 0.2488 | 0.0366 |
| E73 | 190.1458 | 59.80 | 8 | 0.863 | 0.4177 | 0.0603 |
| E74 | 190.1872 | 60.80 | 8 | 0.691 | 0.1388 | 0.0188 |
| E75 | 190.2451 | 61.70 | 8 | 0.649 | 0.1697 | 0.0316 |
| E76 | 190.2715 | 57.30 | 8 | 0.701 | 0.1654 | 0.0623 |
| E77 | 190.3128 | 62.20 | 8 | 0.770 | 0.0740 | 0.0062 |
| E78 | 190.3528 | 62.20 | 8 | 0.775 | 0.1040 | 0.0170 |
| E79 | 190.3944 | 60.90 | 8 | 0.675 | 0.1257 | 0.0239 |
| E80 | 190.4378 | 61.35 | 8 | 0.570 | 0.0617 | 0.0169 |
| E81 | 190.4774 | 60.85 | 8 | 0.601 | 0.0847 | 0.0205 |
| E82 | 190.5194 | 61.00 | 8 | 0.751 | 0.1076 | 0.0255 |
| E83 | 190.5608 | 59.75 | 8 | 0.820 | 0.1525 | 0.0374 |
| E84 | 190.6028 | 61.40 | 8 | 0.795 | 0.1565 | 0.0367 |
| E85 | 190.6552 | 59.10 | 8 | 0.672 | 0.0944 | 0.0175 |
| E86 | 190.6861 | 60.90 | 8 | 0.584 | 0.1725 | 0.0318 |
| E87 | 190.7271 | 60.75 | 8 | 0.462 | 0.0632 | 0.0085 |
| E88 | 190.7688 | 57.75 | 8 | 0.551 | 0.0313 | 0.0134 |
| E89 | 190.8104 | 62.20 | 8 | 0.672 | 0.0568 | 0.0405 |
| E90 | 190.8531 | 62.20 | 8 | 0.721 | 0.0858 | 0.0174 |
| E91 | 190.8997 | 62.20 | 8 | 0.652 | 0.0841 | 0.0086 |
| E92 | 190.9399 | 62.20 | 8 | 0.561 | 0.0326 | 0.0045 |

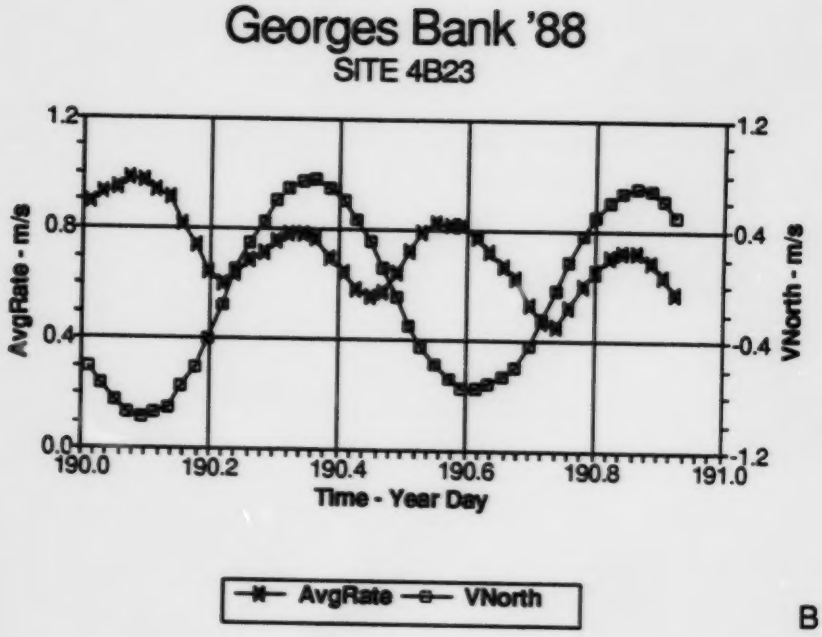
FIGURE 16:

A. Current vector plot for the RCM at 34m depth at site 4 overlapping the EPSONDE anchor station 4B during cruise 88023 (4B23). This anchor station includes EPSONDE stations 70 to 92.

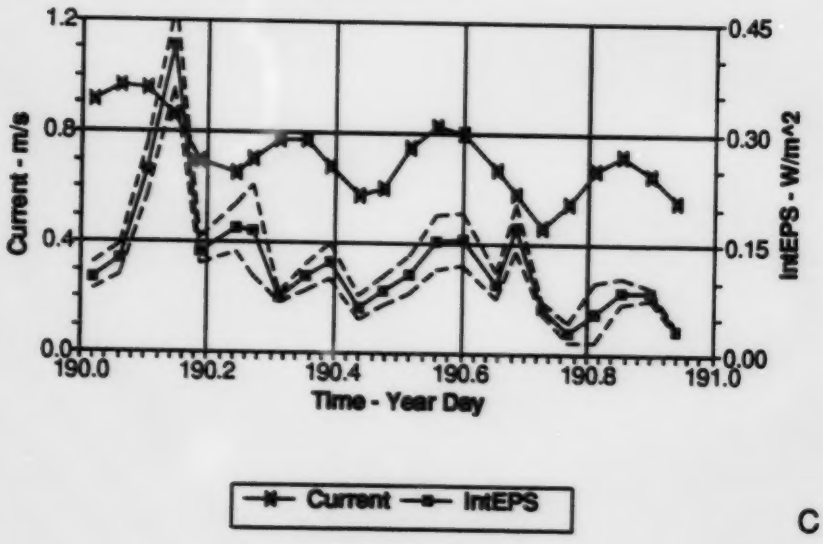
B. The magnitude and the northward component of the vertically averaged composite RCM and Ametek DCP current at half hourly intervals for site 4 coincident with EPSONDE anchor station 4B23.

C. The magnitude of the vertically averaged composite current interpolated to the mean EPSONDE station time and the integrated dissipation, IntEPS, for each EPSONDE station during anchor station 4B23. Error limits are indicated for IntEPS.




Georges Bank '88
SITE 4B23
AvgRate - m/s
VNorth - m/s
Time - Year Day
AvgRate
VNorth

B

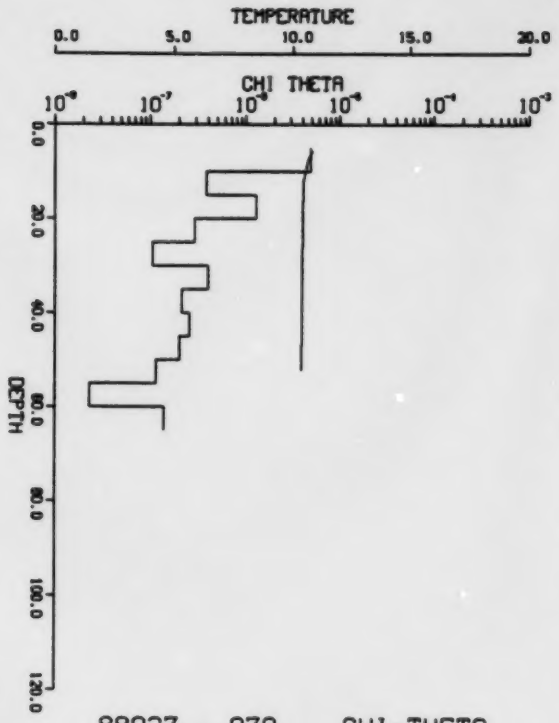

Microstructure Anchor Station
SITE 4B23
Current - m/s
IntEPS - W/m^2
Time - Year Day
Current
IntEPS

C

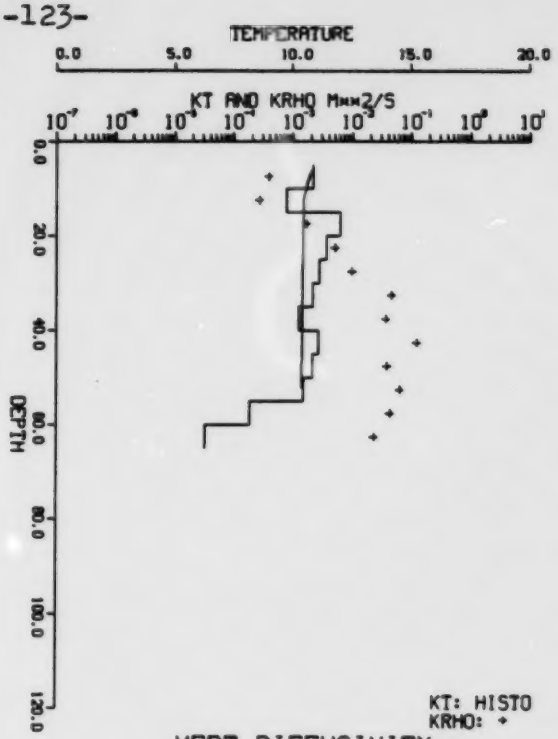
FIGURE 17: Profiles of microstructure quantities for stations 70 to 92 for anchor station 4B23.
- Each page contains a profile of a microstructure quantity averaged over 5 m vertical bins overlaid on a profile of temperature.
- The upper left panel is Chi-Theta, the dissipation of temperature variance.
- The upper right panel contains profiles of vertical diffusivity KT (for temperature) and KRHO for density.
- The lower left panel contains a profile of dissipation, EPSILON.
- The lower right panel shows the profile for Cox number.

The stations are shown in the following order:

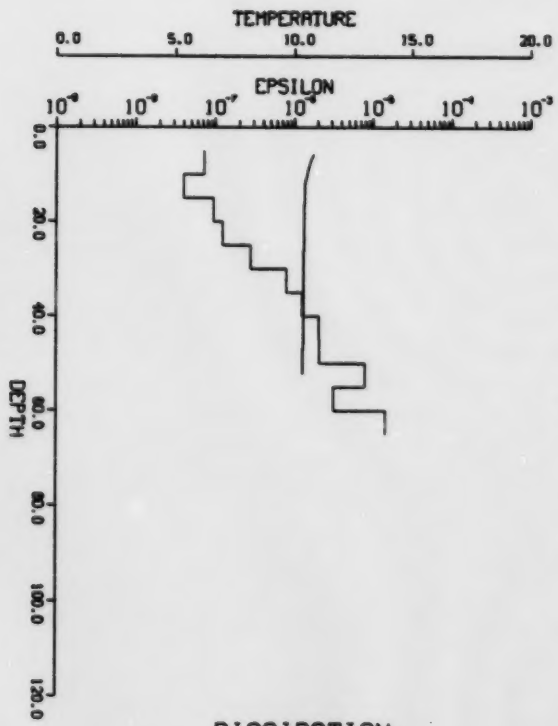
A. Station 70
B. Station 71
C. Station 72
D. Station 73
E. Station 74
F. Station 75
G. Station 76
H. Station 77
I. Station 78
J. Station 79
K. Station 80
L. Station 81
M. Station 82
N. Station 83
O. Station 84
P. Station 85
Q. Station 86
R. Station 87
S. Station 88
T. Station 89
U. Station 90
V. Station 91
W. Station 92



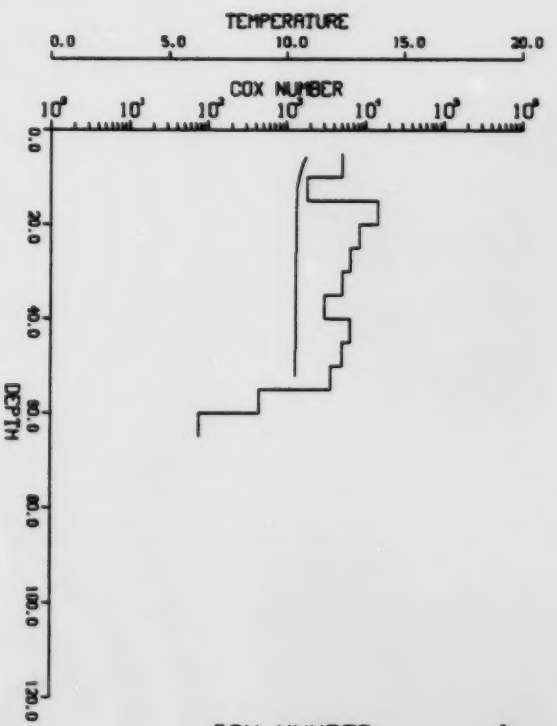

88023 - 070 CHI-THETA



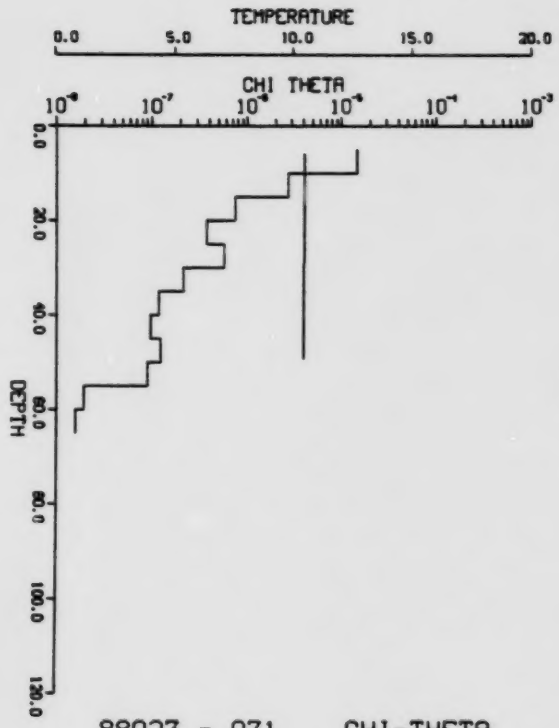

VERT DIFFUSIVITY




DISSIPATION

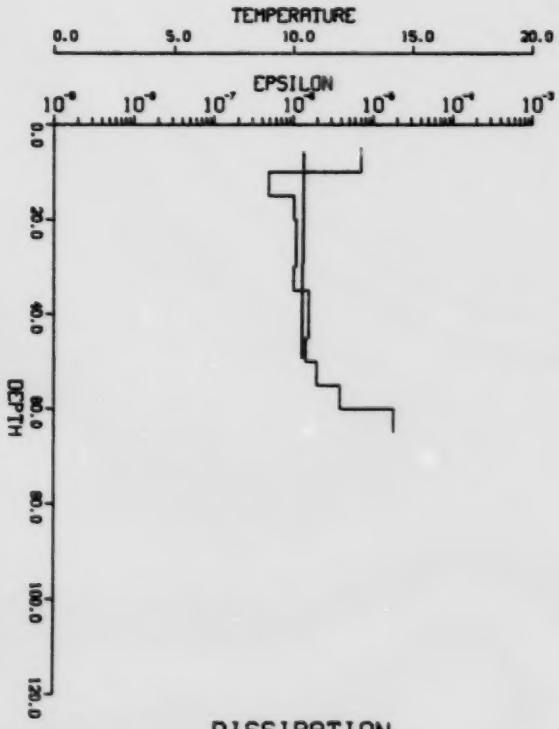



COX NUMBER A




88023 - 071 CHI-THETA

VERT DIFFUSIVITY

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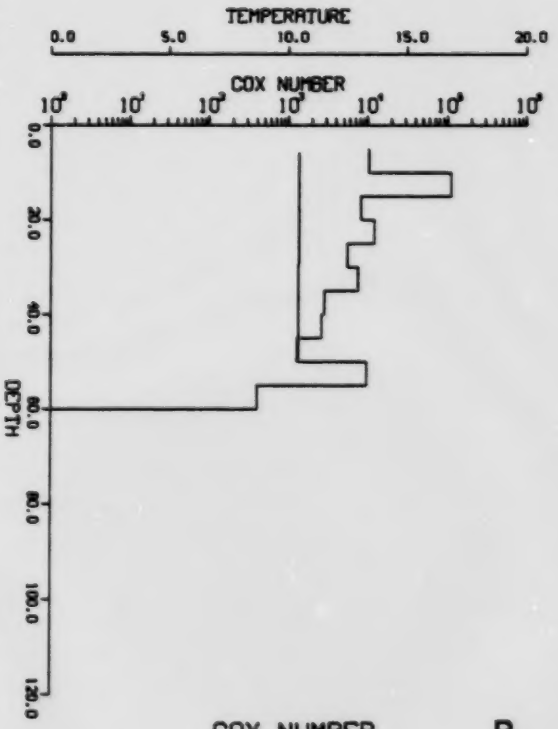
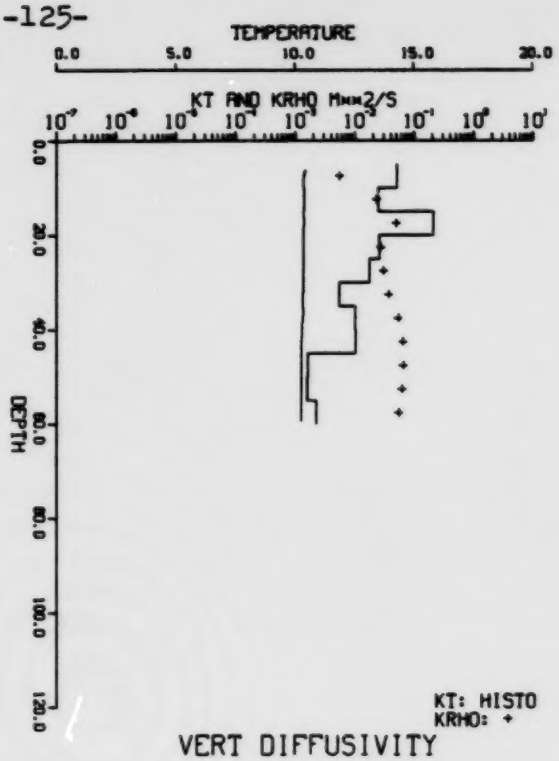
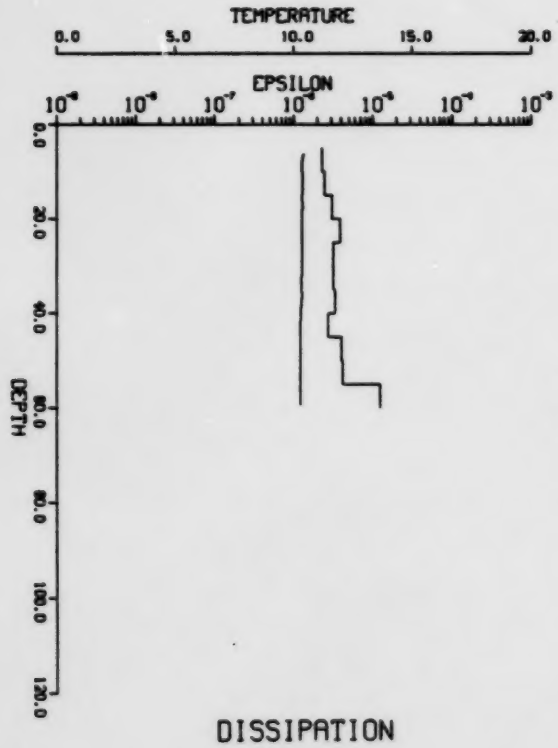



COX NUMBER B

88023 - 072 CHI-THETA




VERT DIFFUSIVITY

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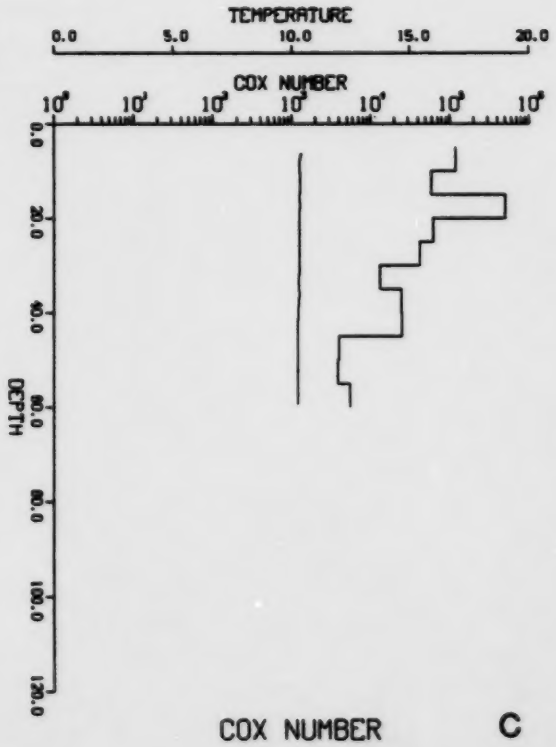
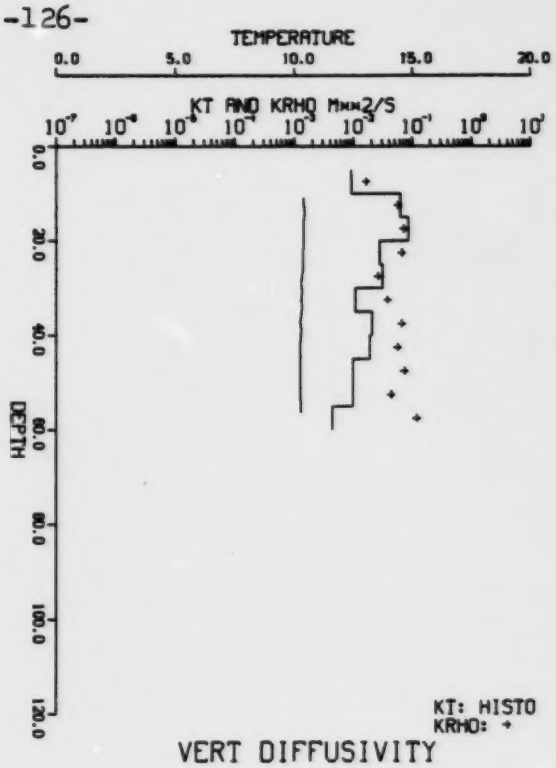



COX NUMBER

C

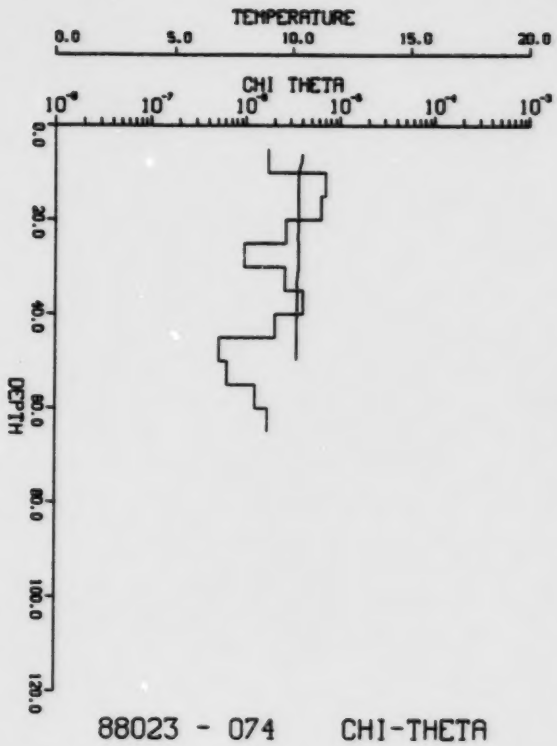
88023 - 073 CHI-THETA



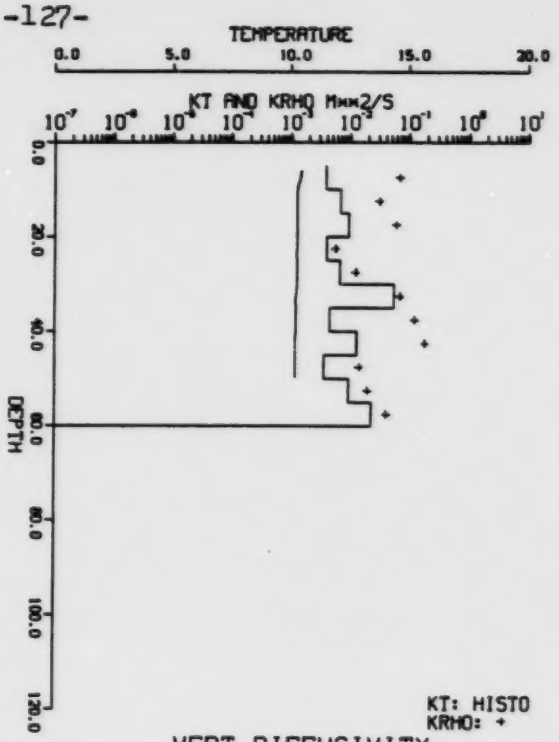

VERT DIFFUSIVITY

DISSIPATION

COX NUMBER D




88023 - 074 CHI-THETA

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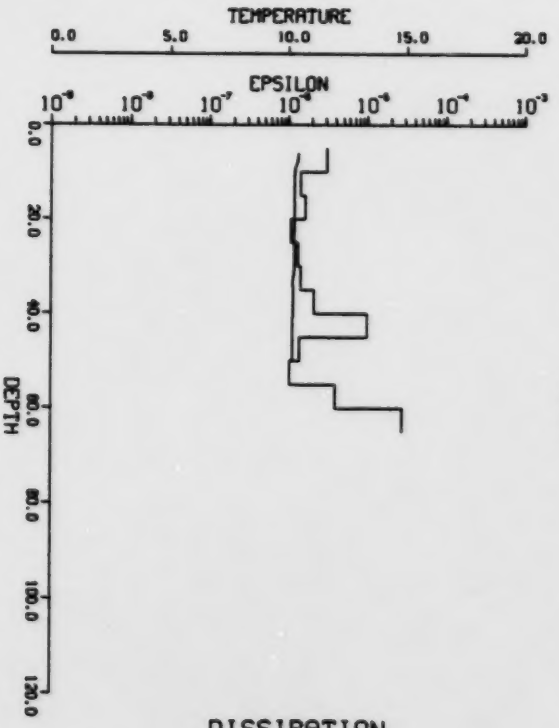


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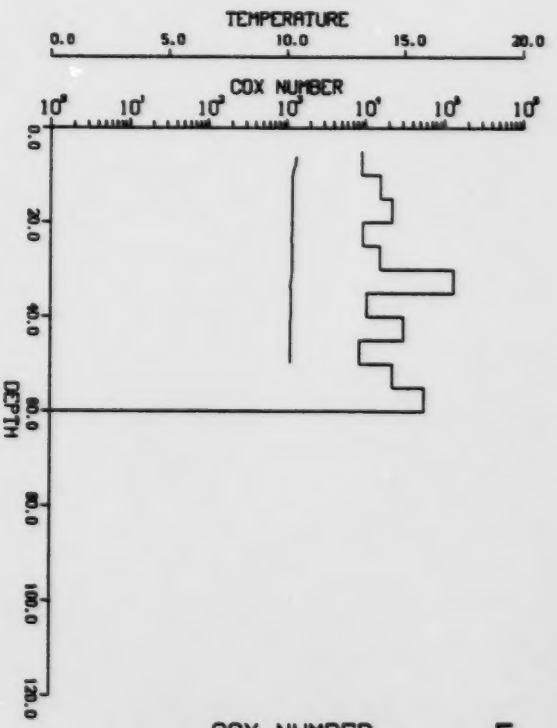
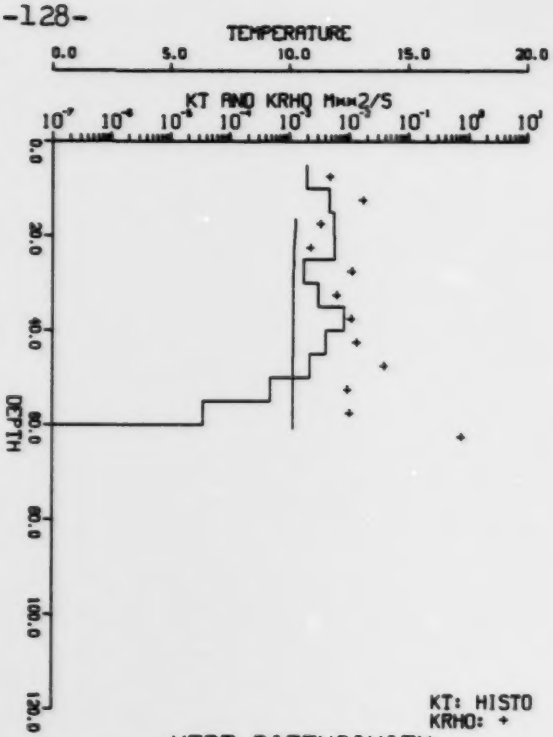
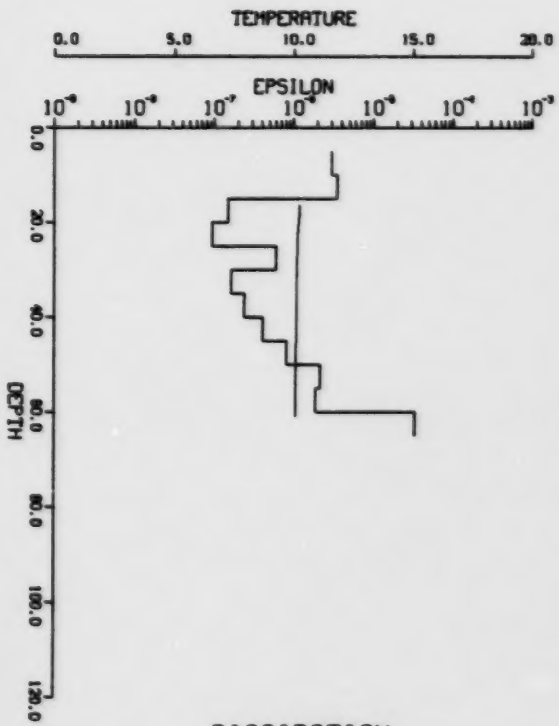



COX NUMBER E

88023 - 075 CHI-THETA




VERT DIFFUSIVITY

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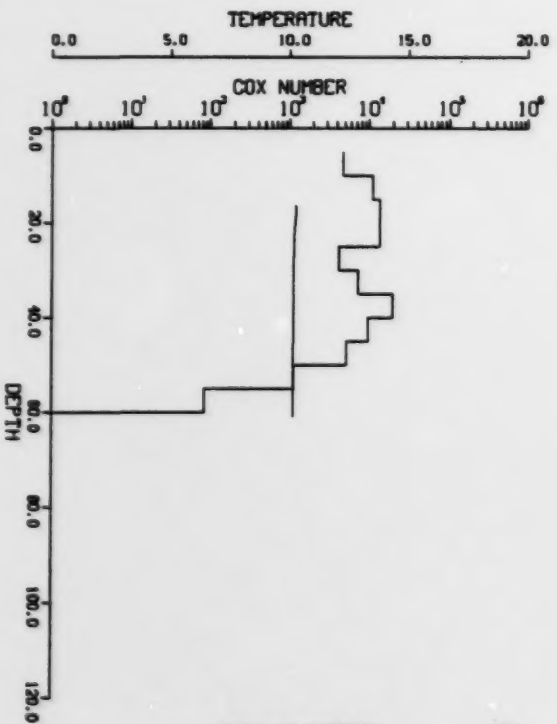
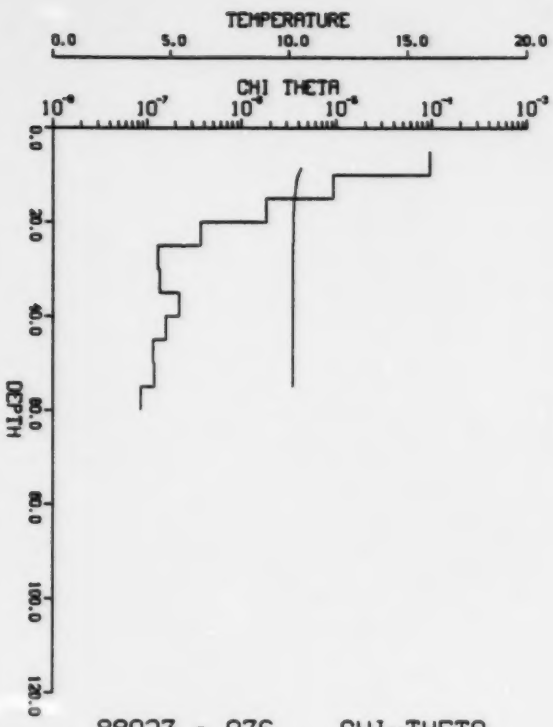
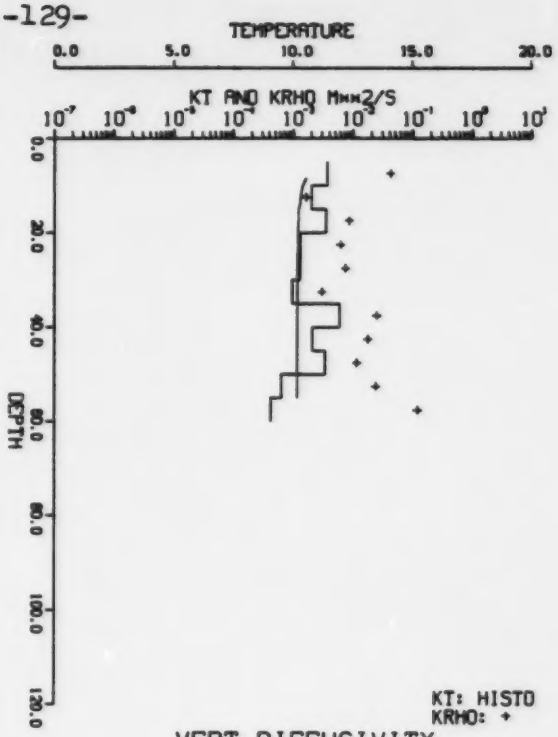



COX NUMBER

F




88023 - 076 CHI-THETA

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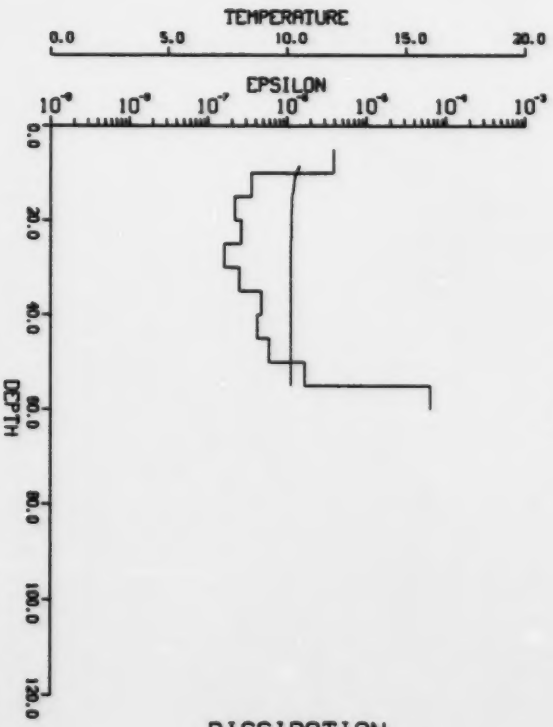


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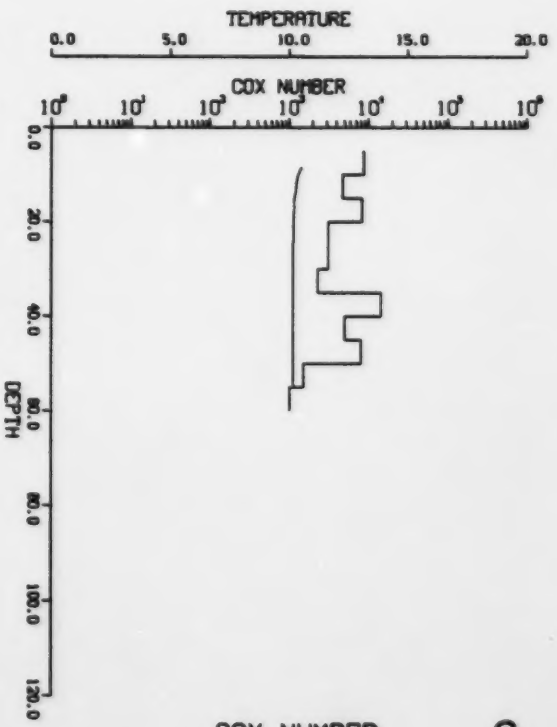


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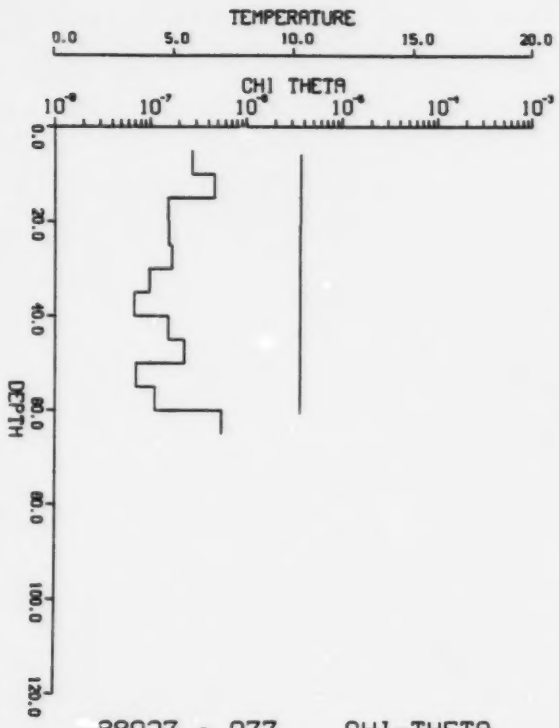
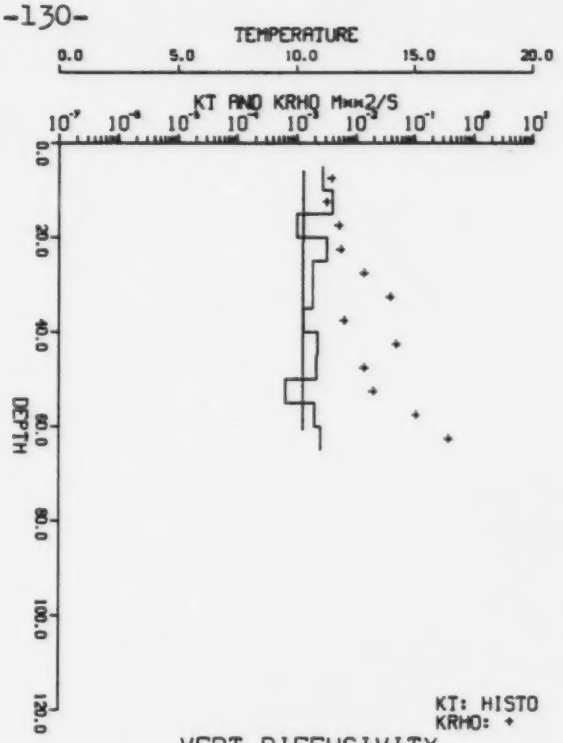



88023 - 077 CHI-THETA

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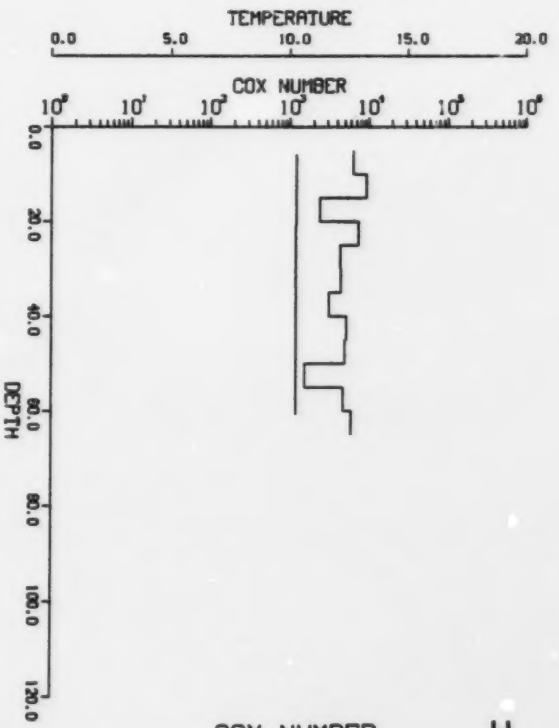


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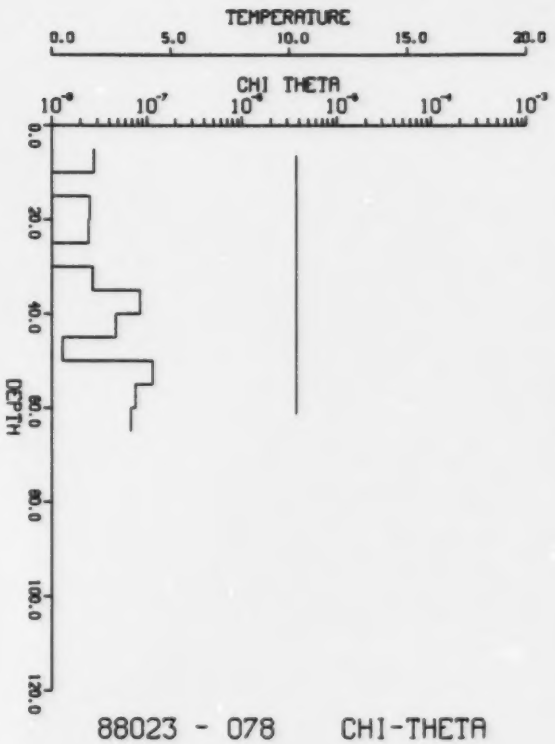
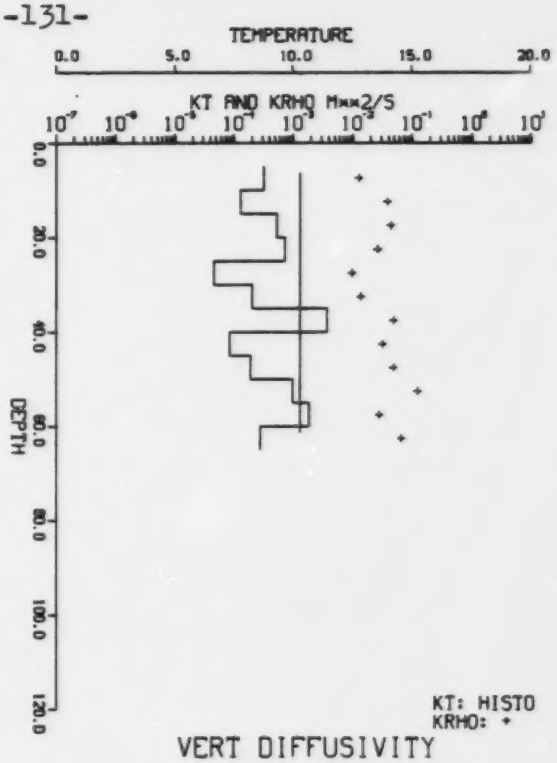



88023 - 078 CHI-THETA

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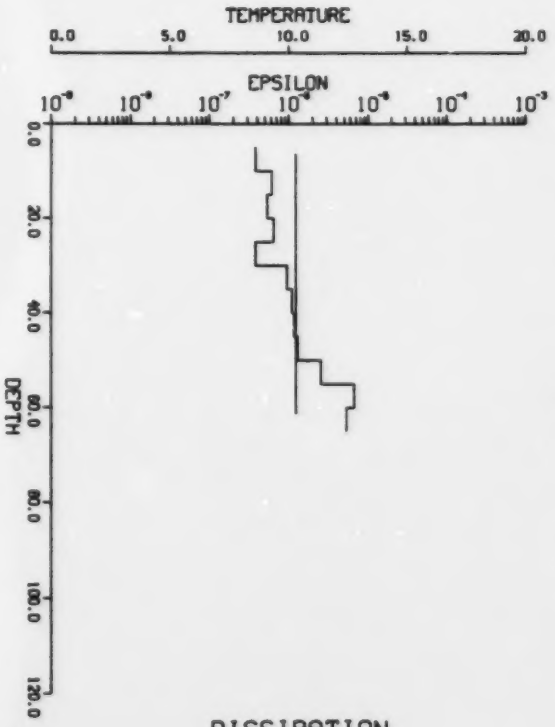


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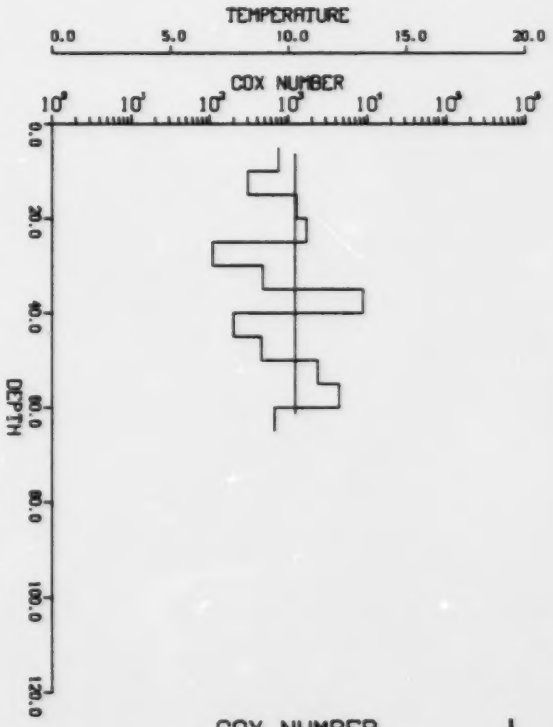


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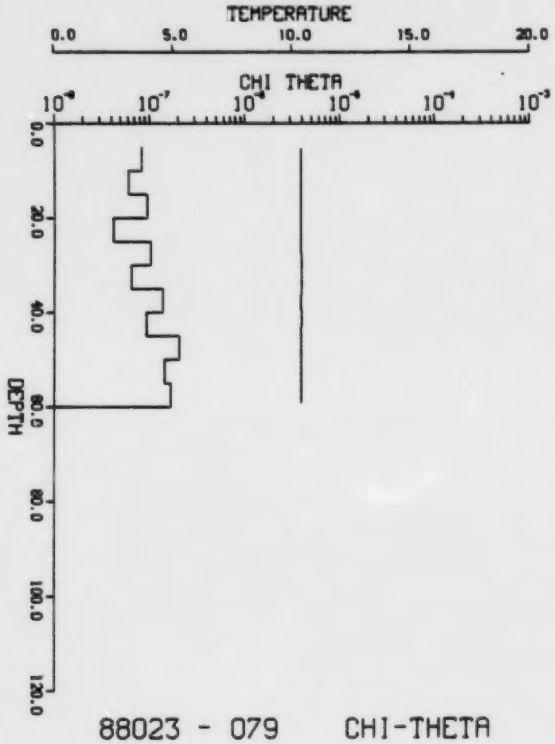
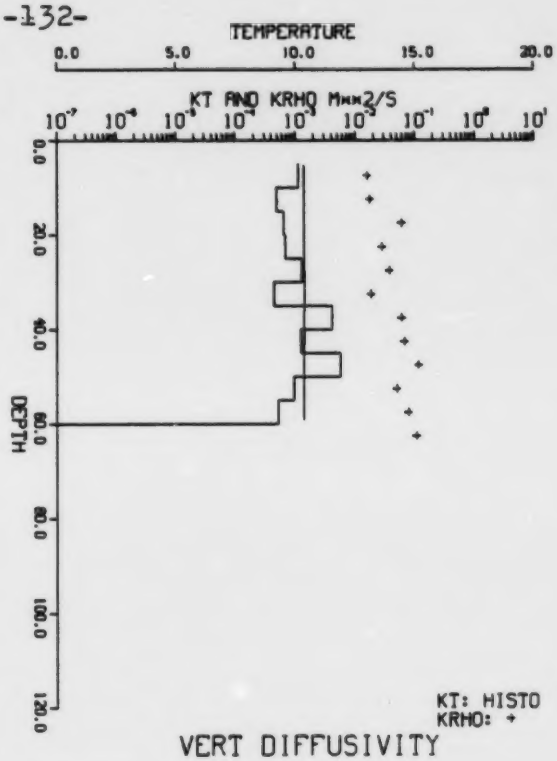



88023 - 079 CHI-THETA

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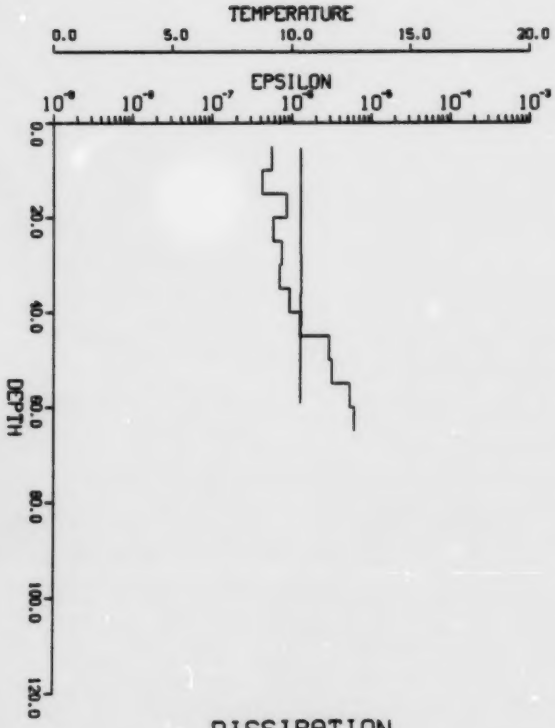


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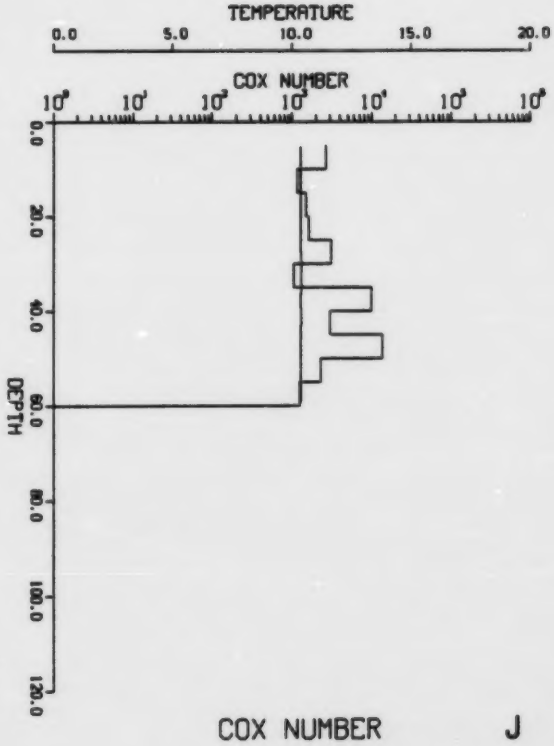


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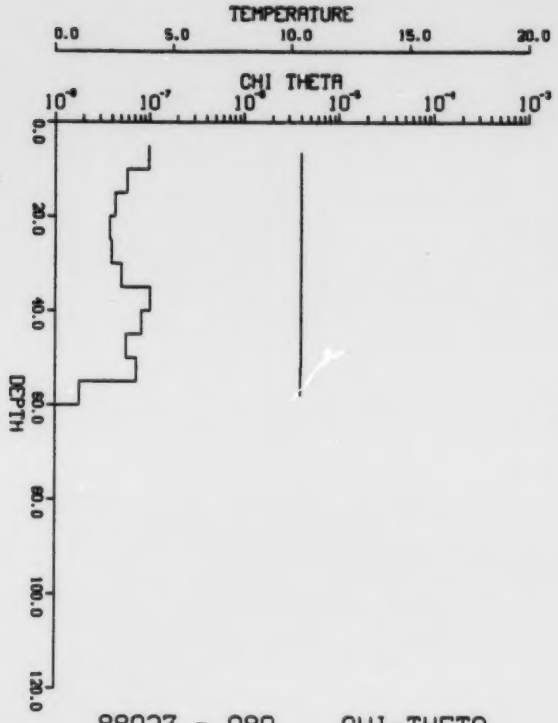
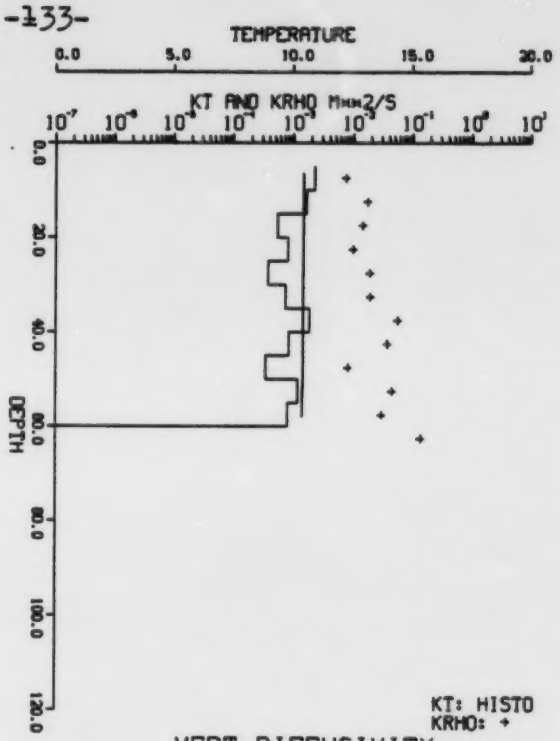



88023 - 080 CHI-THETA

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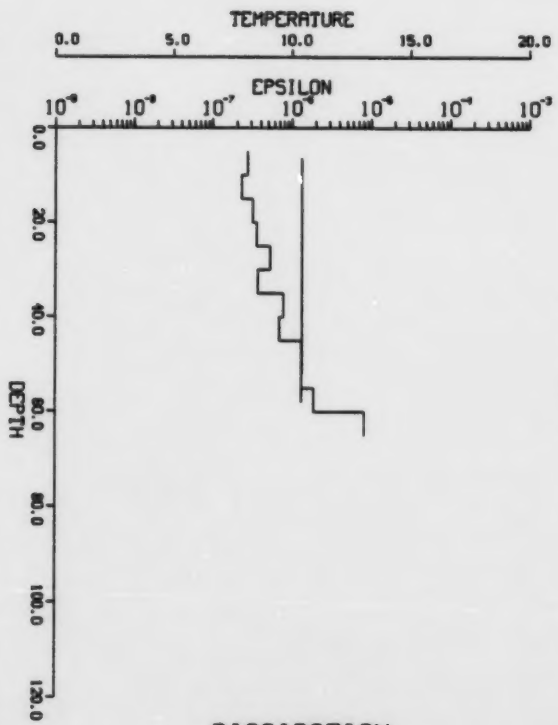


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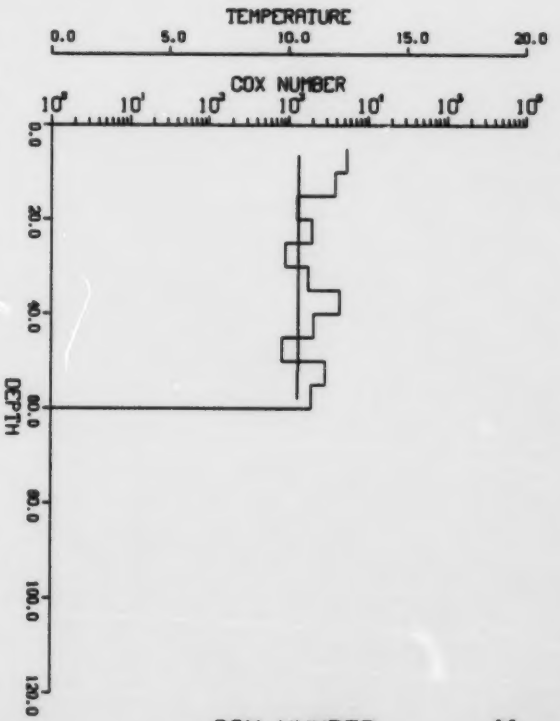


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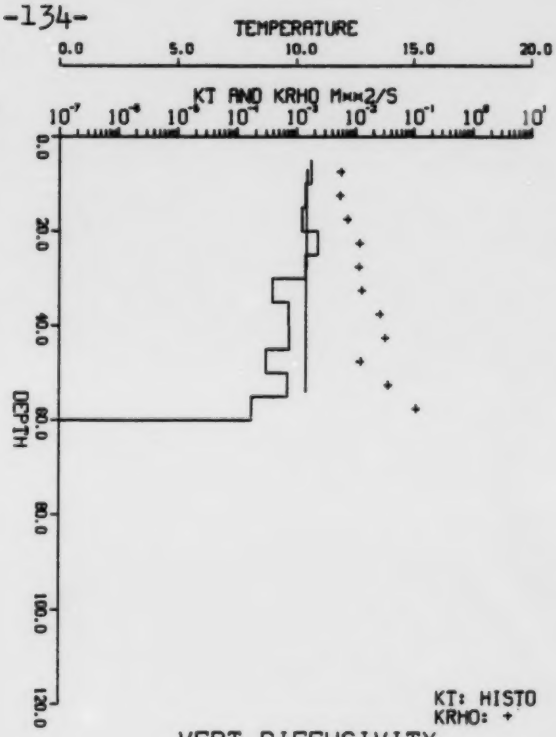
88023 - 081 CHI-THETA

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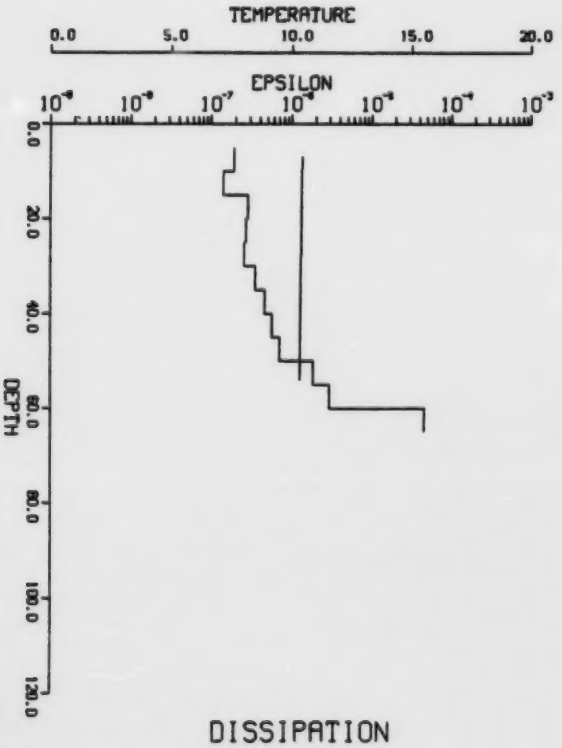


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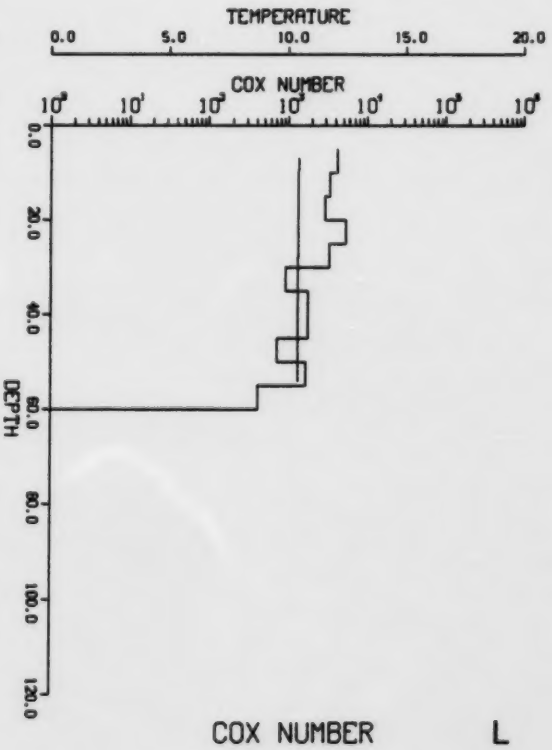


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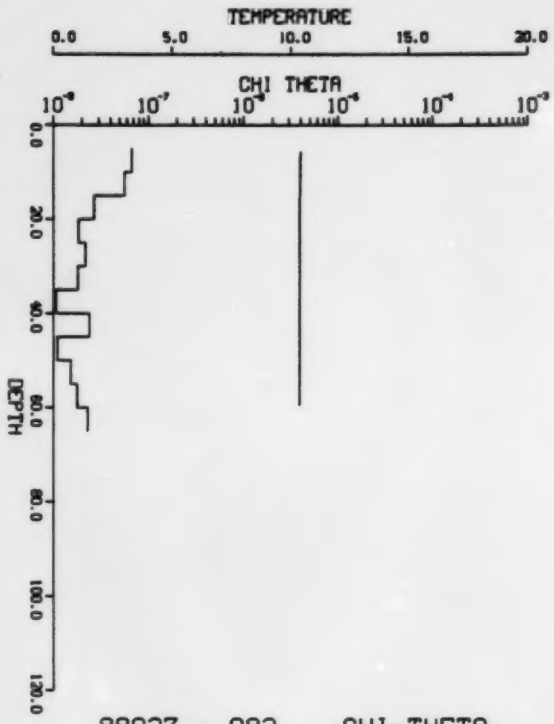
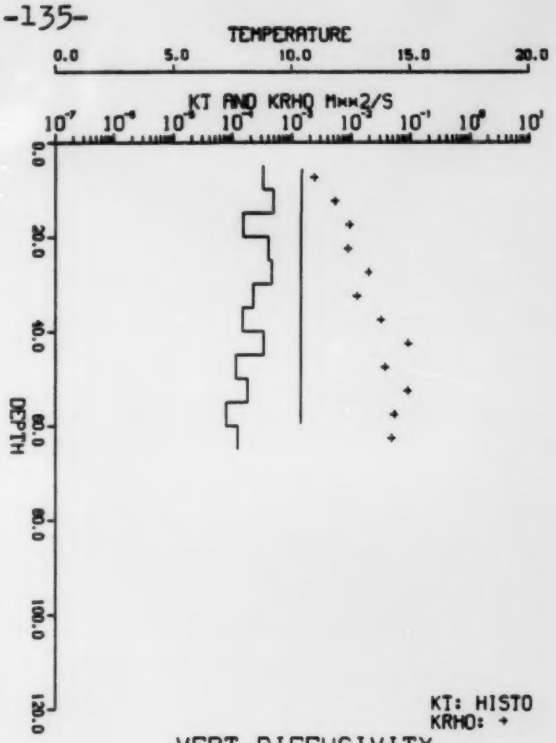



88023 - 082 CHI-THETA

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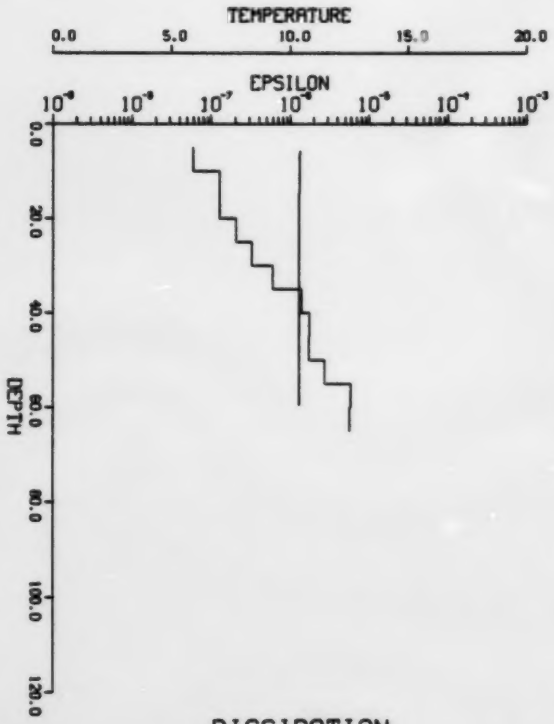


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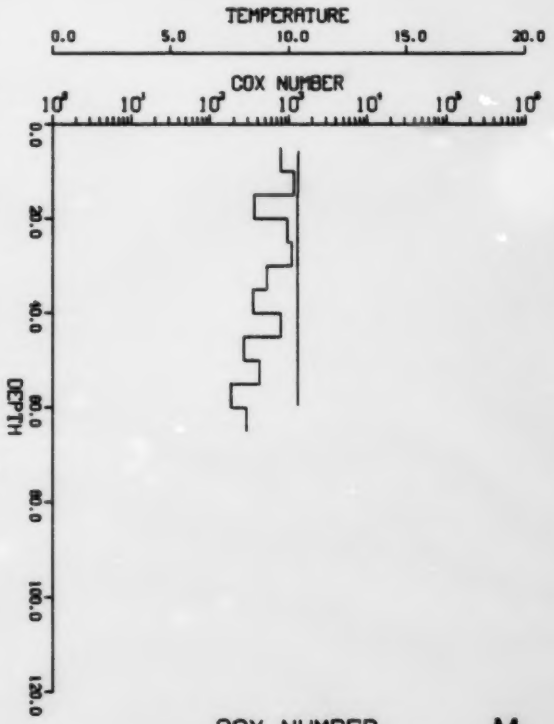


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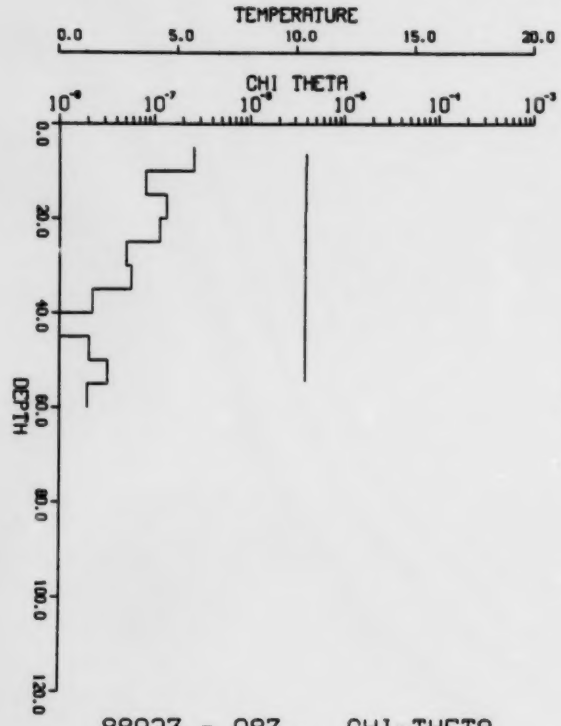
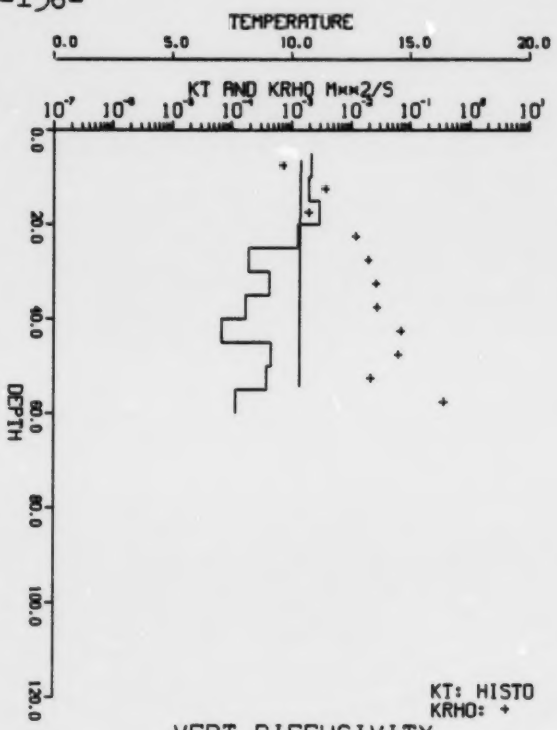



88023 - 083 CHI-THETA

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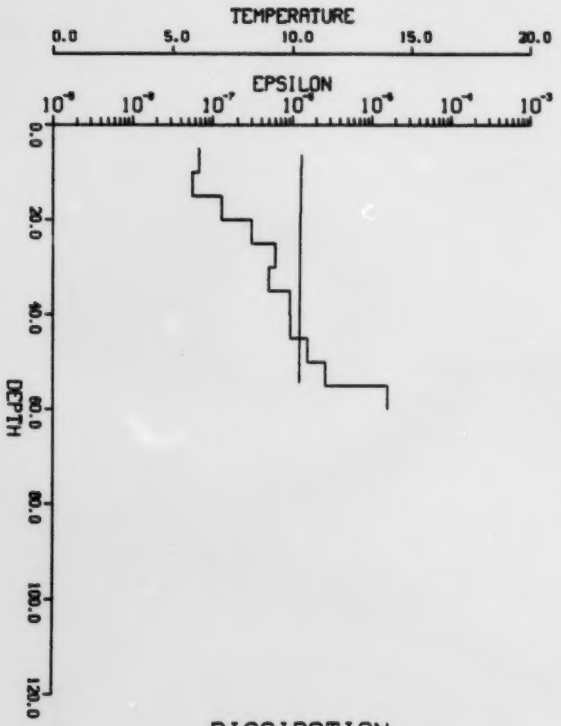


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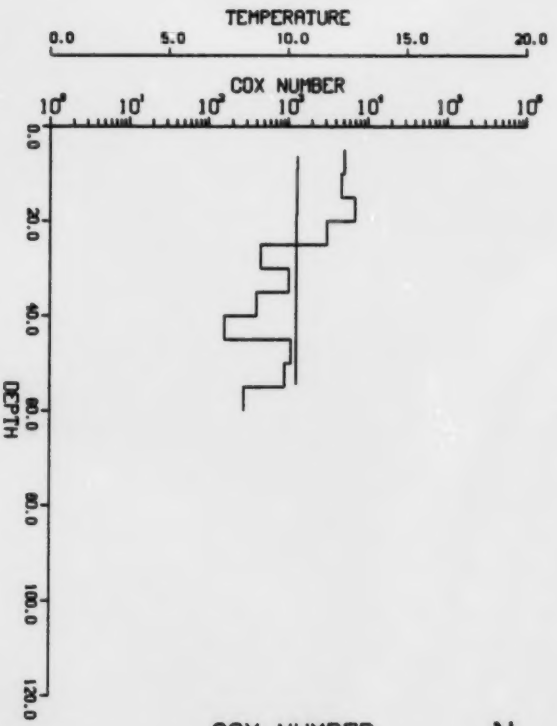


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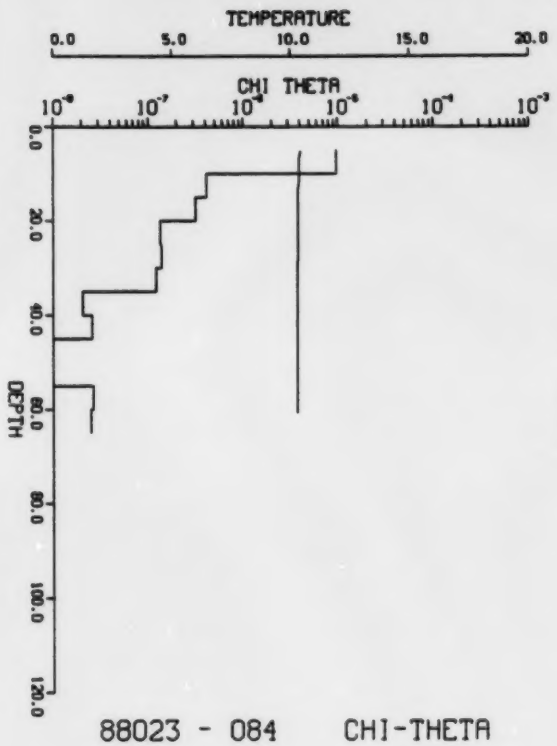
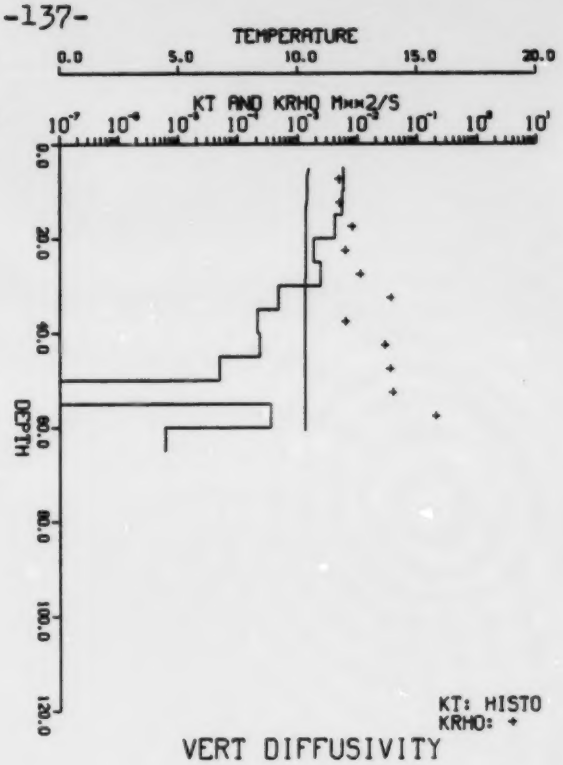



88023 - 084 CHI-THETA

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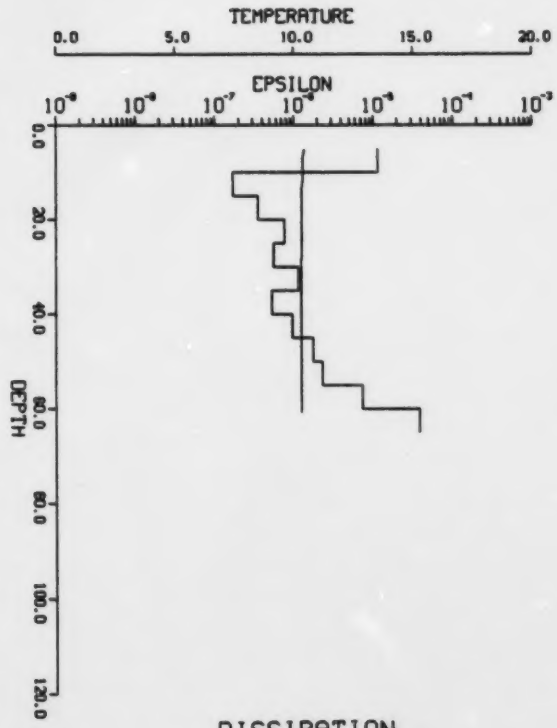


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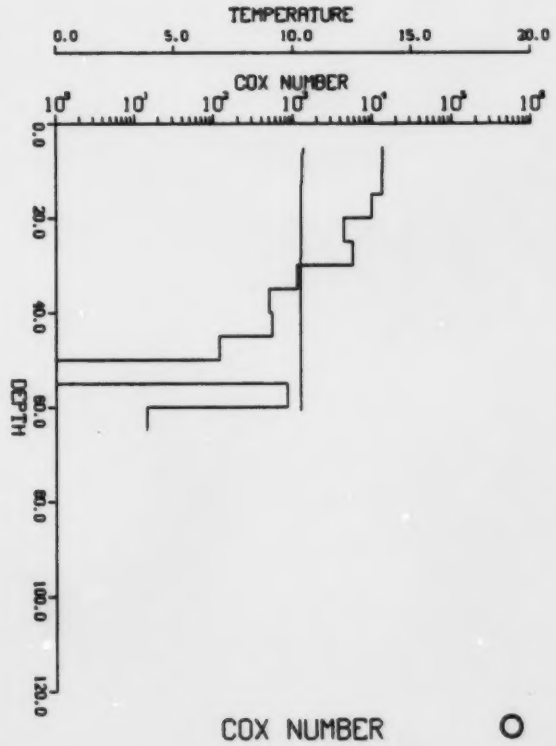


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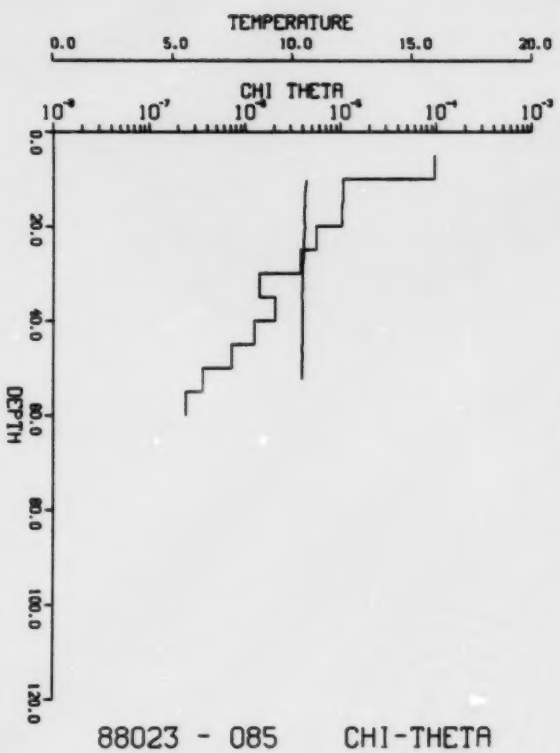
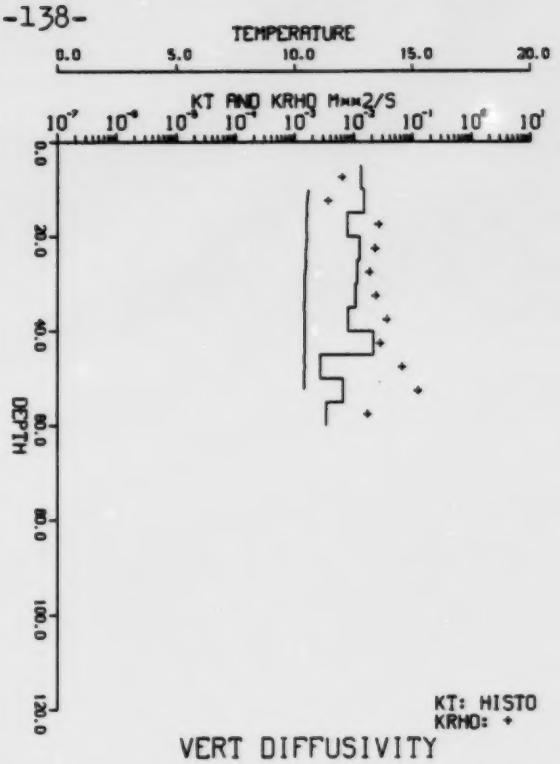



88023 - 085 CHI-THETA

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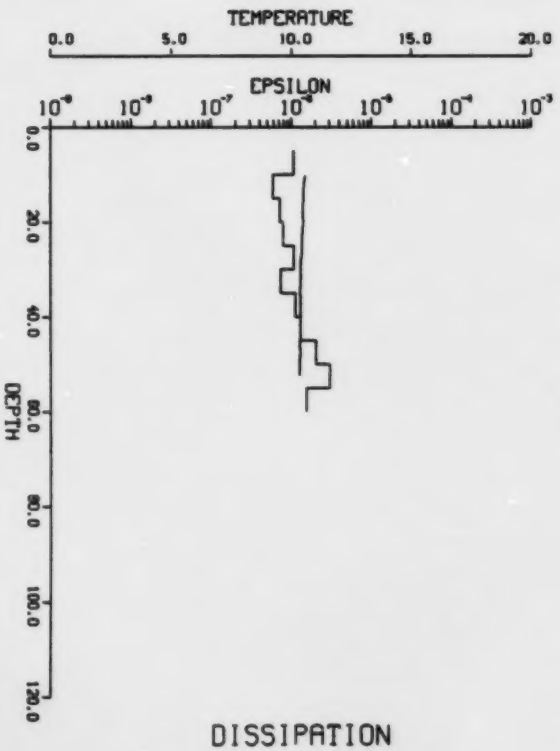


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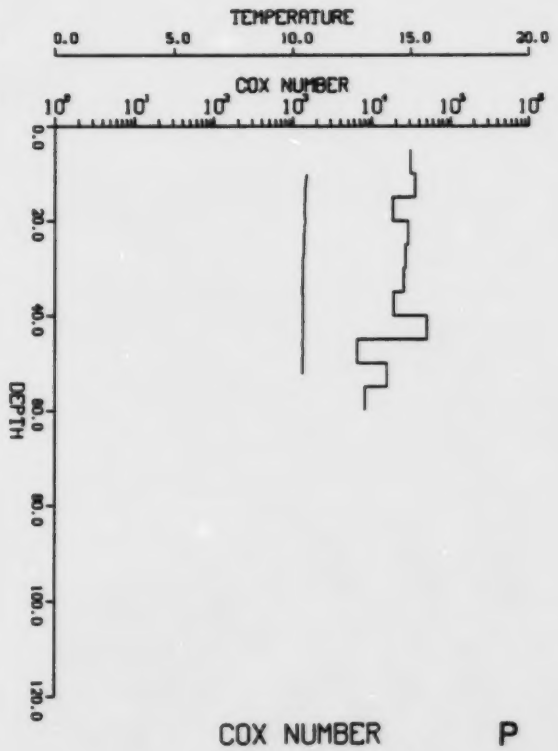
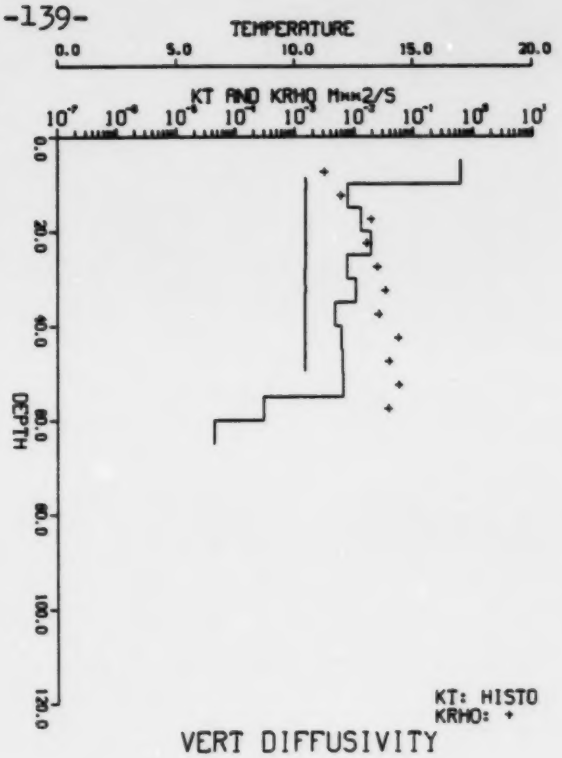



COX NUMBER P

88023 - 086 CHI-THETA

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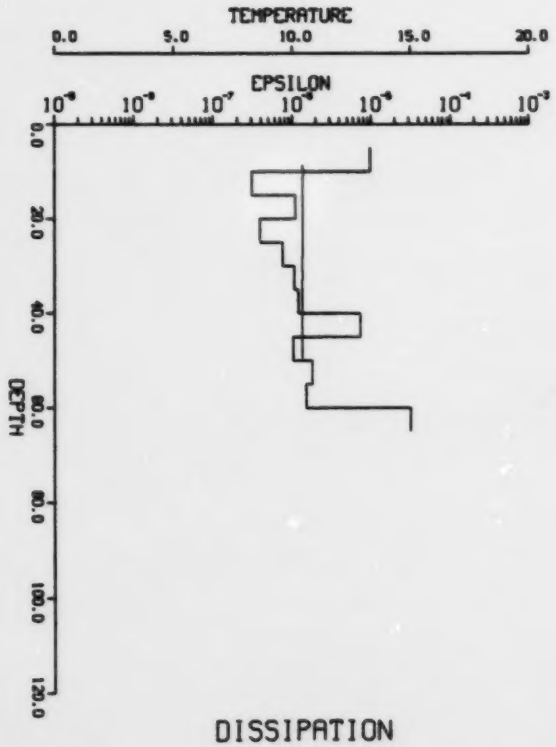


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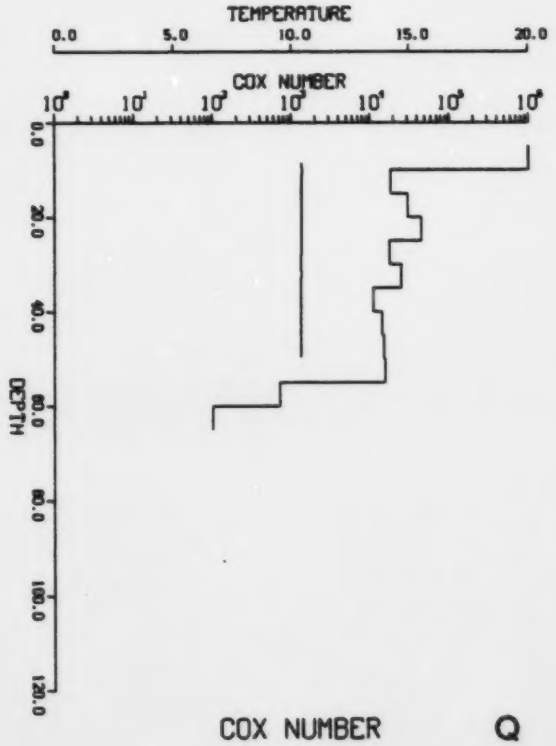


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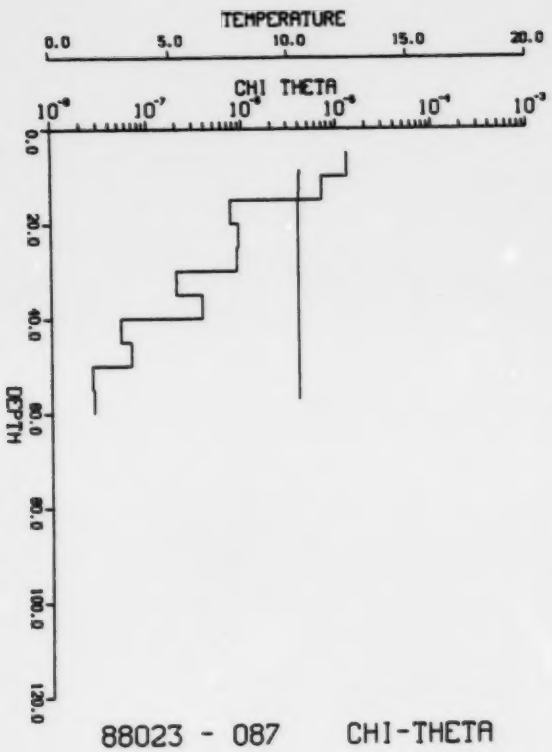
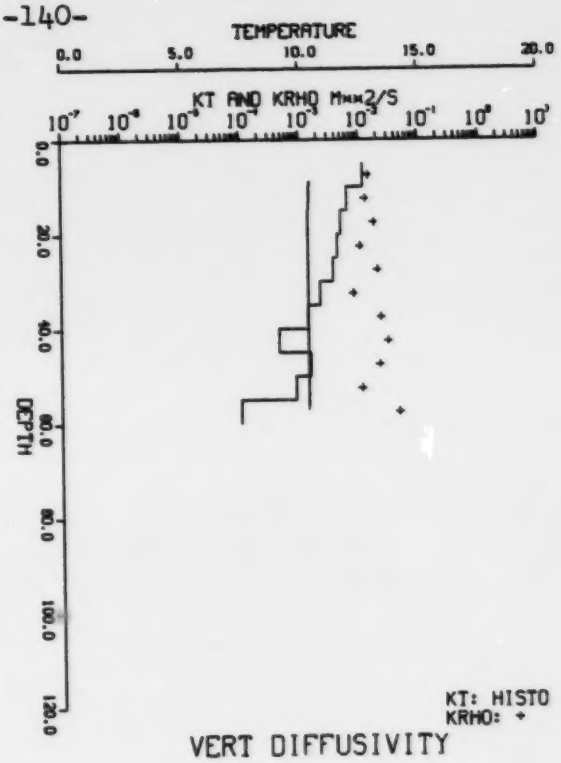



88023 - 087 CHI-THETA

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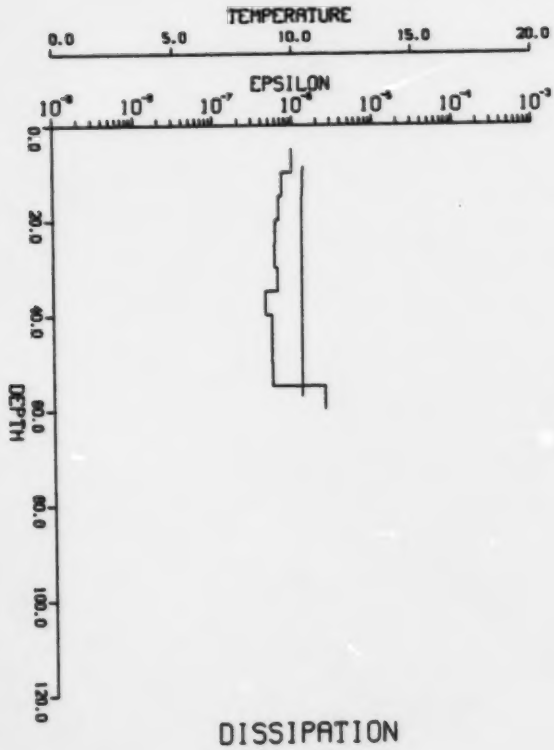


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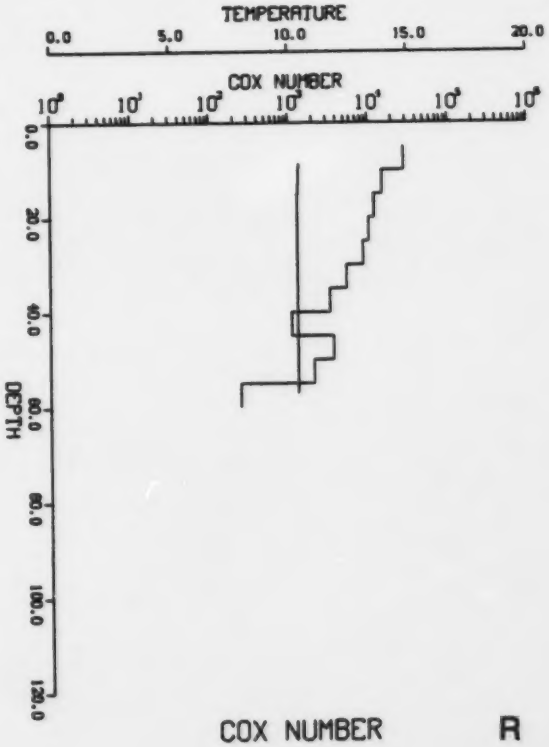


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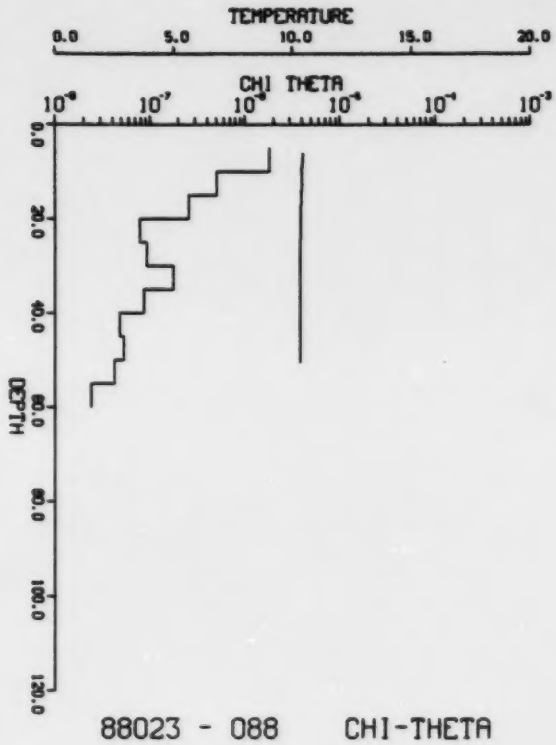


88023 - 088 CHI-THETA

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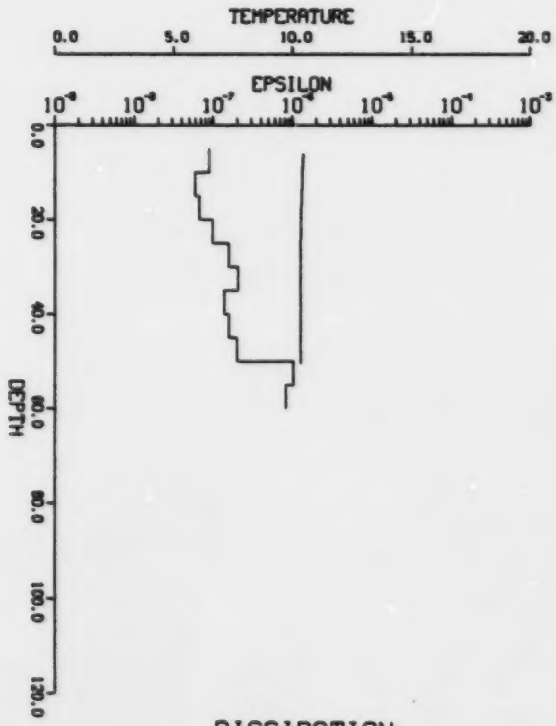


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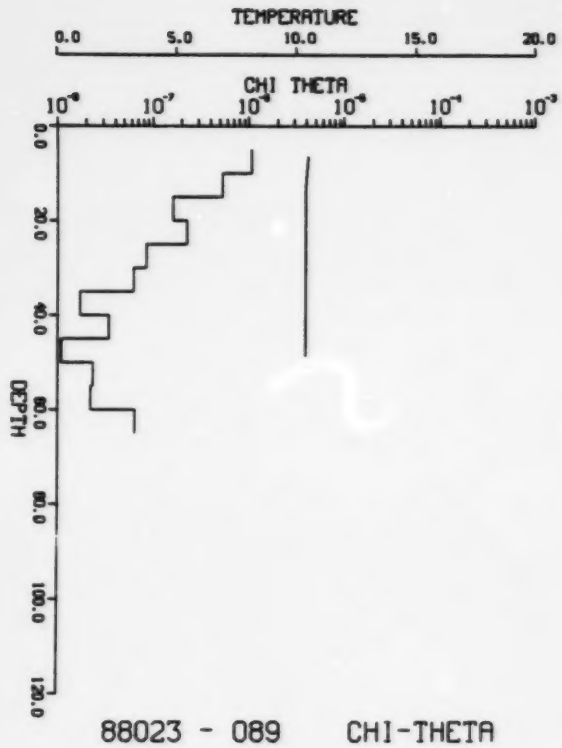
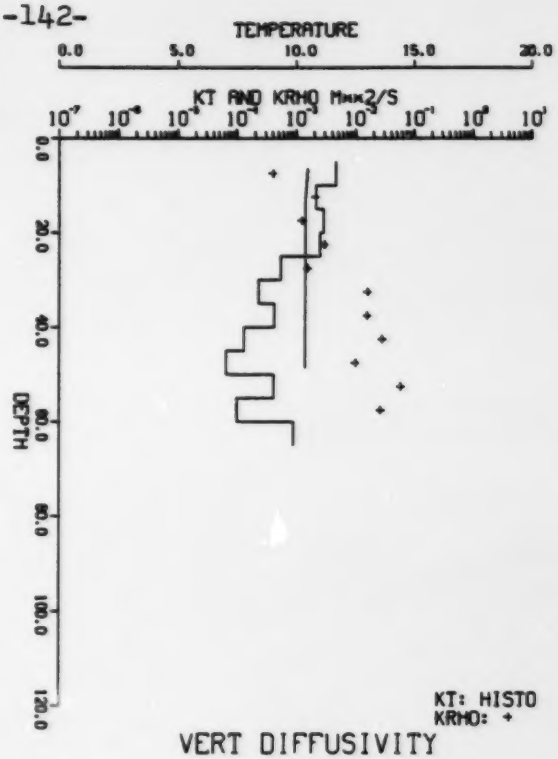



88023 - 089 CHI-THETA

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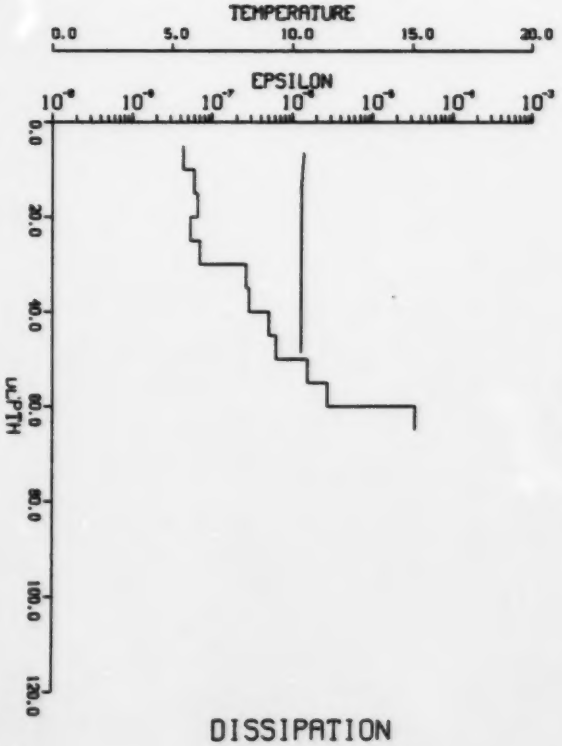
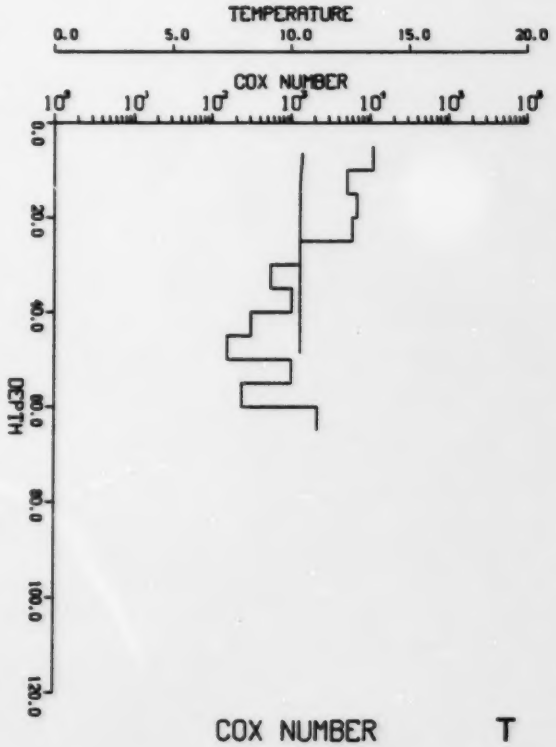
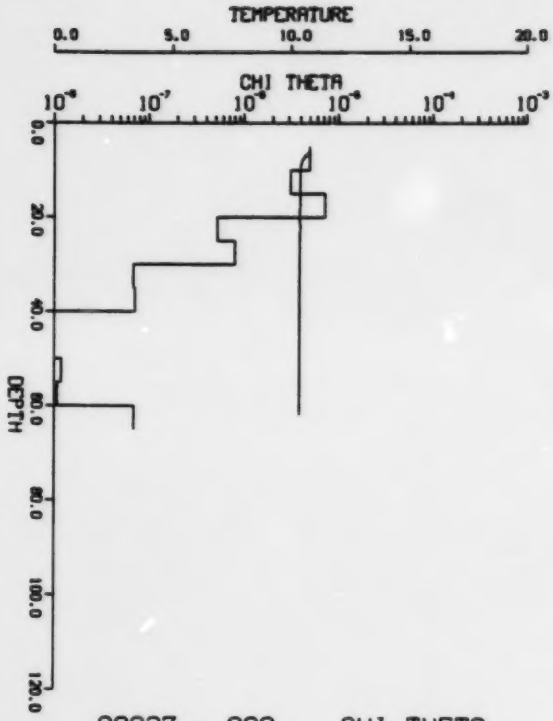


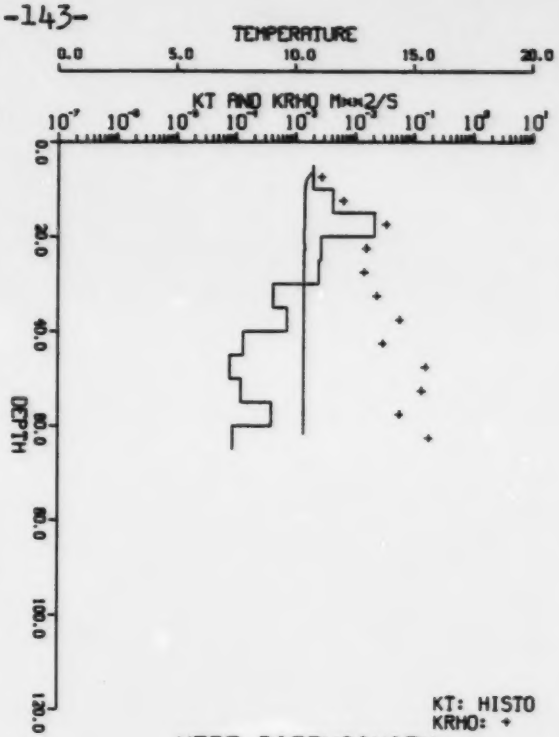

DISSIPATION



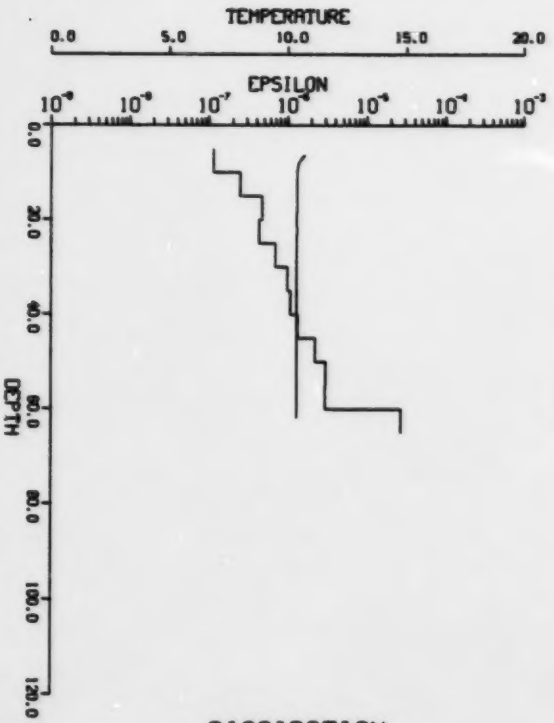

COX NUMBER T




88023 - 090 CHI-THETA




VERT DIFFUSIVITY

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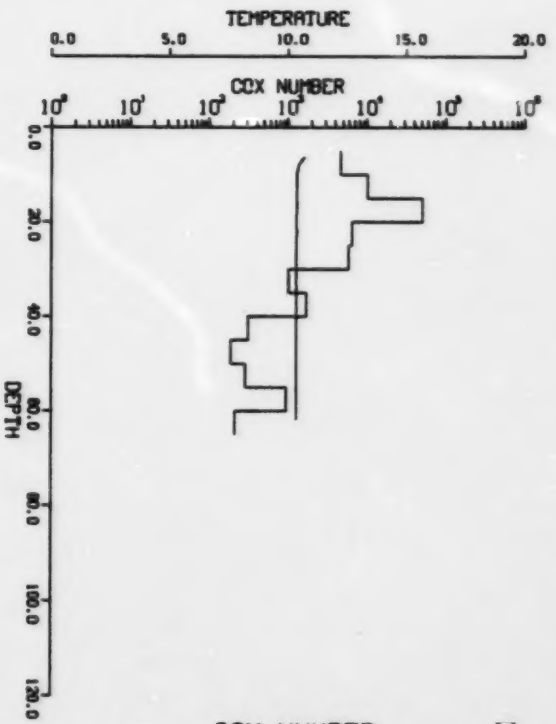
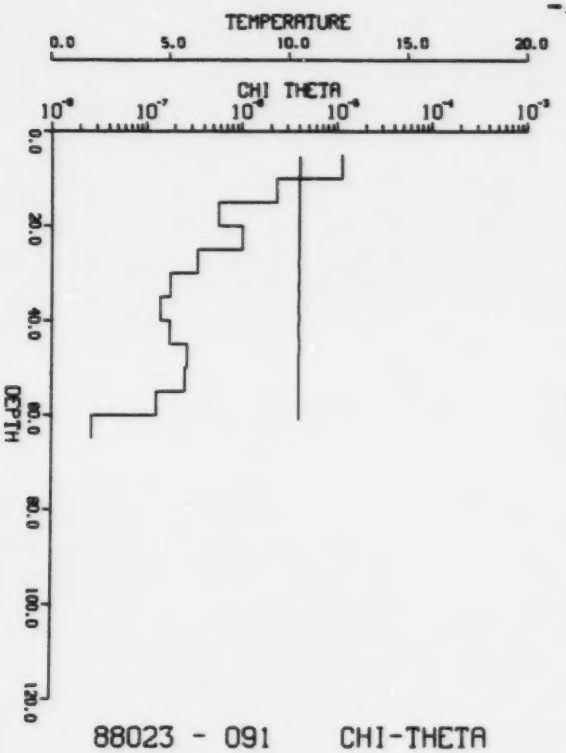
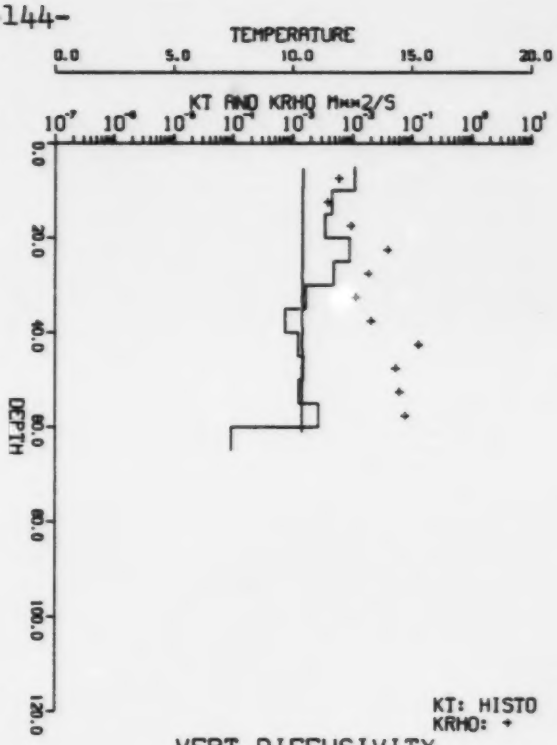


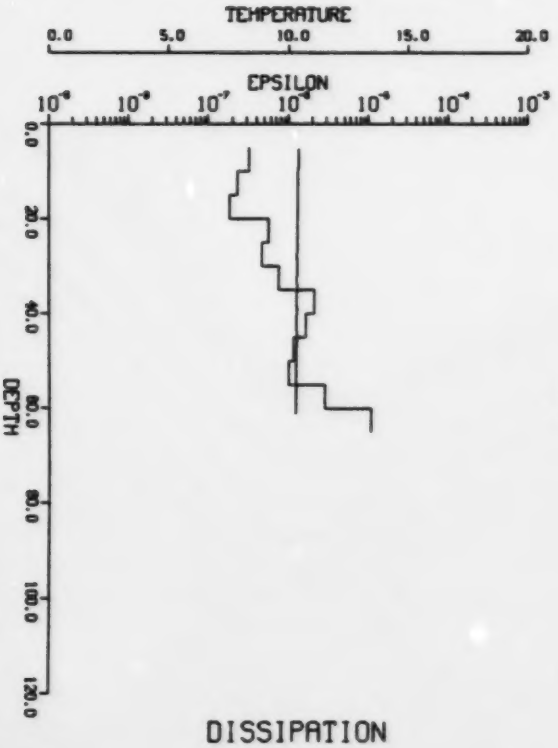

COX NUMBER U



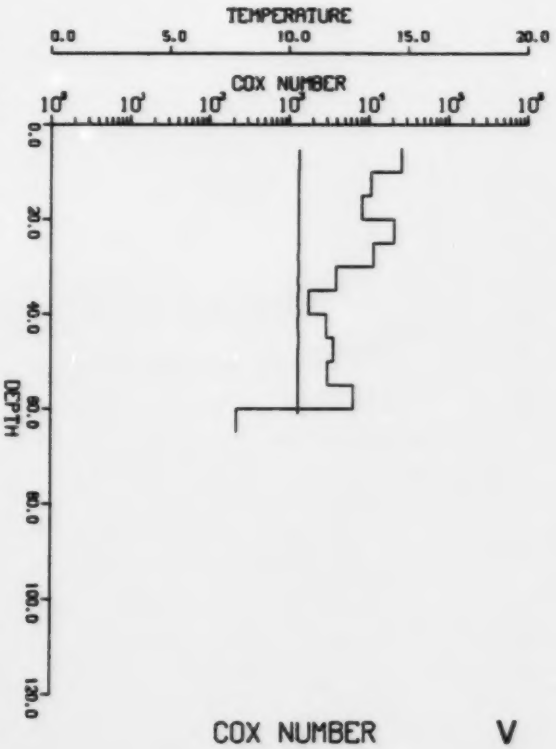

88023 - 091 CHI-THETA



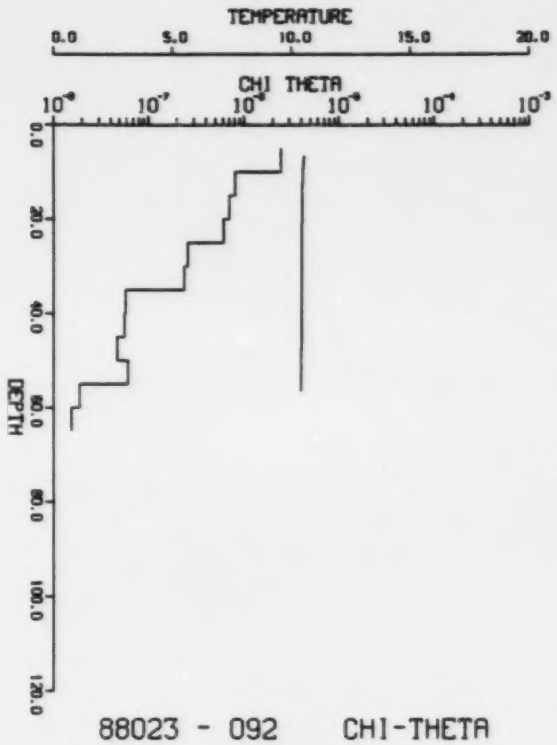

VERT DIFFUSIVITY



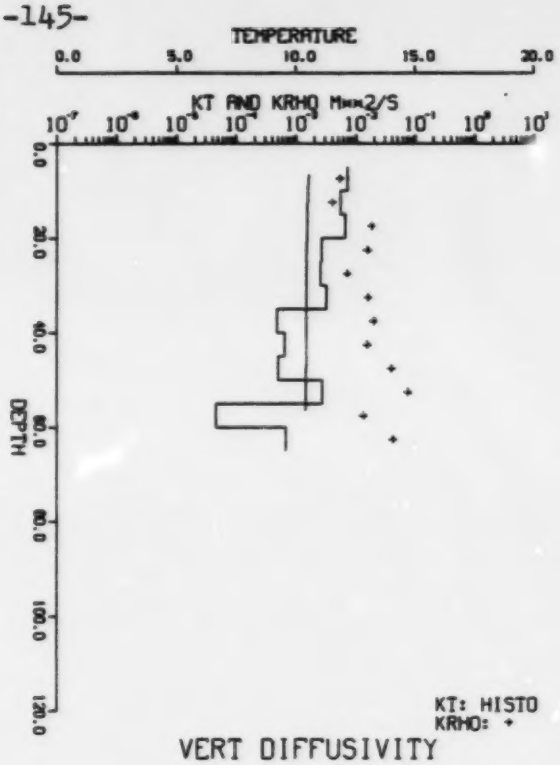

DISSIPATION



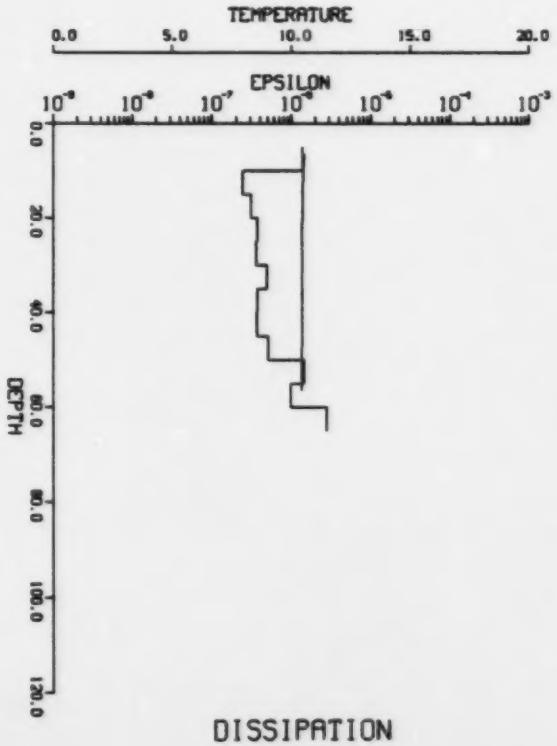

COX NUMBER V




88023 - 092 CHI-THETA




VERT DIFFUSIVITY




DISSIPATION

COX NUMBER W

# SITE 5A23

42°08.29N, 66°29.39W

TABLE 8: COMBINED CURRENT AND DISSIPATION

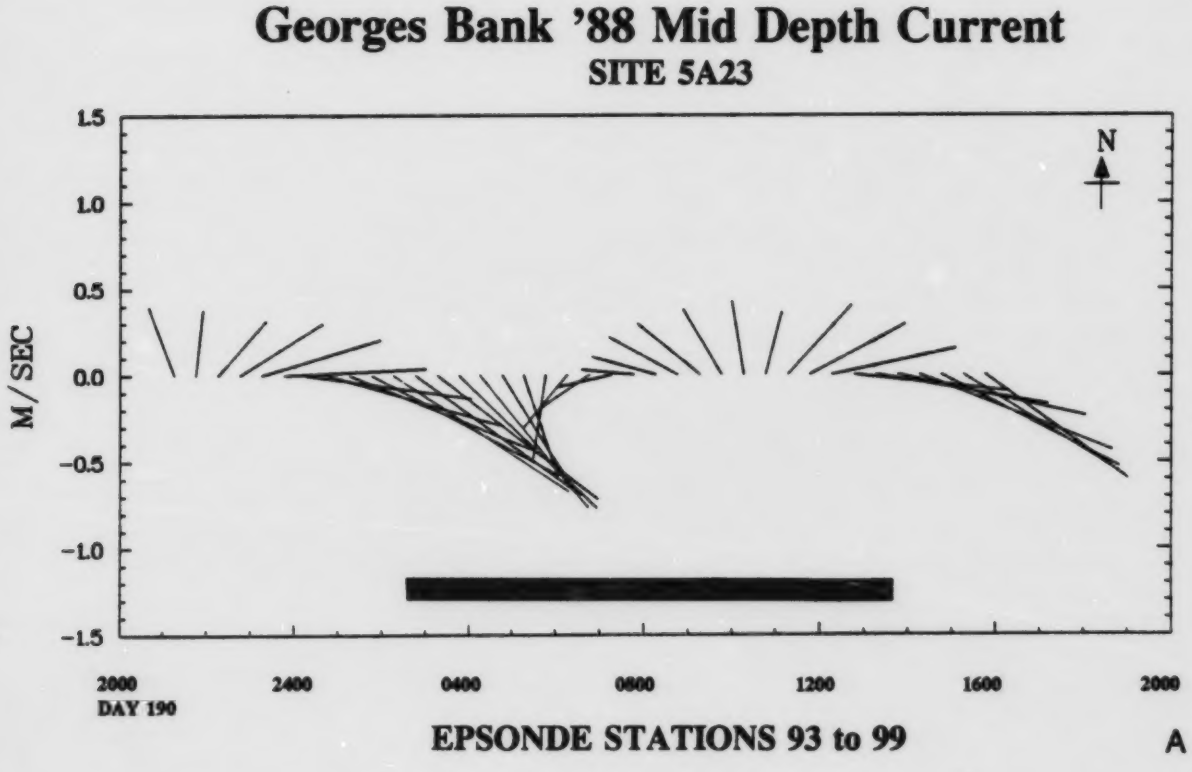
| Station | TimeEPS | Depth | Drops | Current | IntEPS | ErrEPS |
|---|---|---|---|---|---|---|
| E93 | 191.1201 | 102.65 | 8 | 0.714 | 0.0419 | 0.0127 |
| E94 | 191.1833 | 103.70 | 8 | 0.441 | 0.0231 | 0.0034 |
| E95 | 191.2431 | 106.35 | 8 | 0.100 | 0.0194 | 0.0049 |
| E96 | 191.3688 | 114.30 | 7 | 0.396 | 0.0631 | 0.0048 |
| E97 | 191.4292 | 116.20 | 8 | 0.303 | 0.0515 | 0.0075 |
| E98 | 191.4938 | 116.20 | 8 | 0.395 | 0.1696 | 0.0623 |
| E99 | 191.5545 | 103.55 | 8 | 0.597 | 0.0055 | 0.0011 |

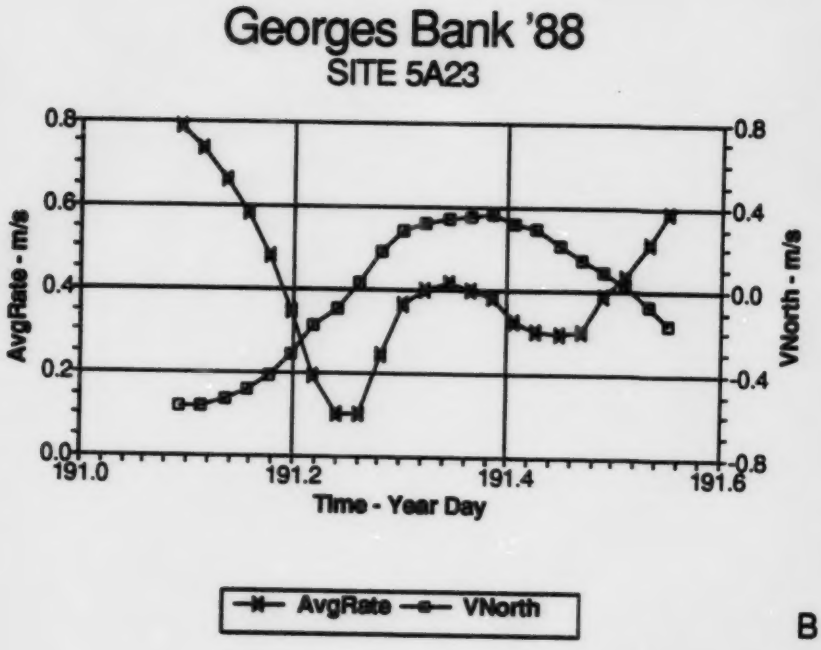
FIGURE 18:

A. Current vector plot for the RCM at 39m depth at site 5 overlapping the EPSONDE anchor station 5A during cruise 88023 (5A23). This anchor station includes EPSONDE stations 93 to 99.

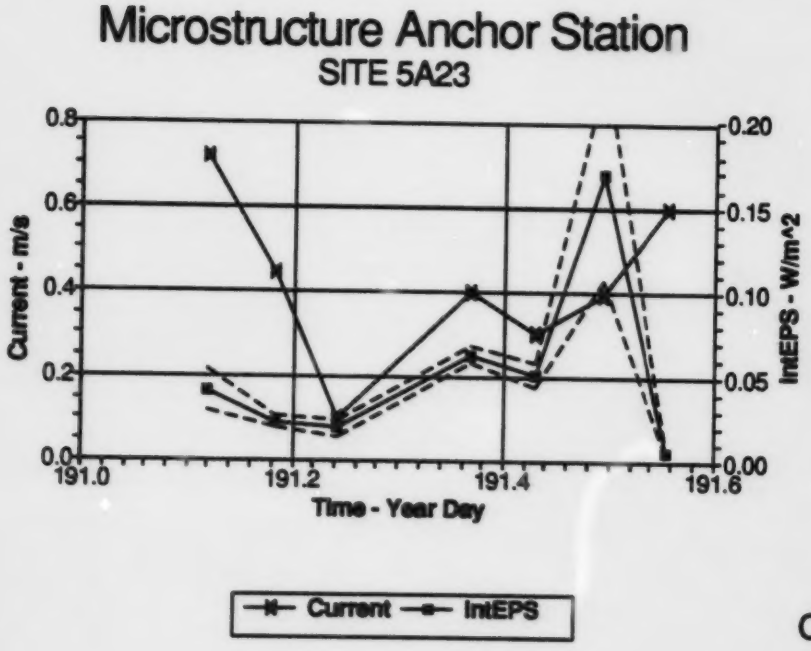
B. The magnitude and the northward component of the vertically averaged composite RCM and Ametek DCP current at half hourly intervals for site 5 coincident with EPSONDE anchor station 5A23.

C. The magnitude of the vertically averaged composite current interpolated to the mean EPSONDE station time and the integrated dissipation, IntEPS, for each EPSONDE station during anchor station 5A23. Error limits are indicated for IntEPS.




Georges Bank '88
SITE 5A23
AvgRate - m/s
VNorth - m/s
Time - Year Day
0.8
0.6
0.4
0.2
0.0
-0.4
-0.8
191.0
191.2
191.4
191.6
AvgRate
VNorth

B

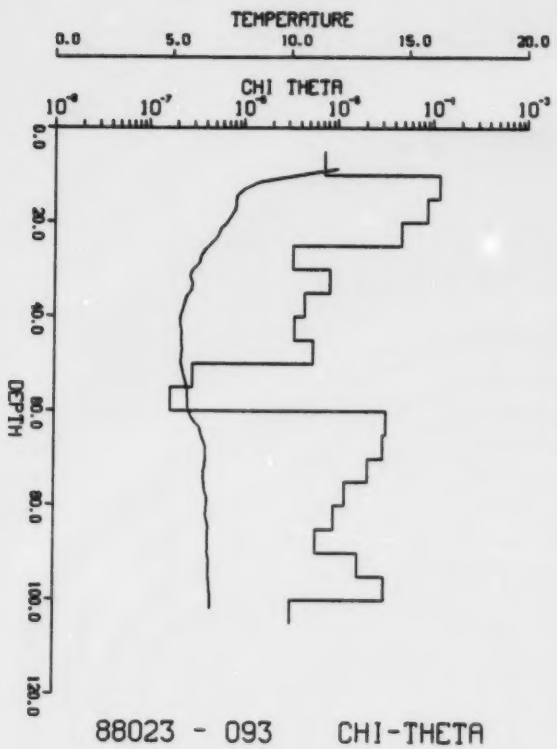

Microstructure Anchor Station
SITE 5A23
Current - m/s
IntEPS - W/m^2
Time - Year Day
0.8
0.6
0.4
0.2
0.0
0.20
0.15
0.10
0.05
0.00
191.0
191.2
191.4
191.6
Current
IntEPS

C

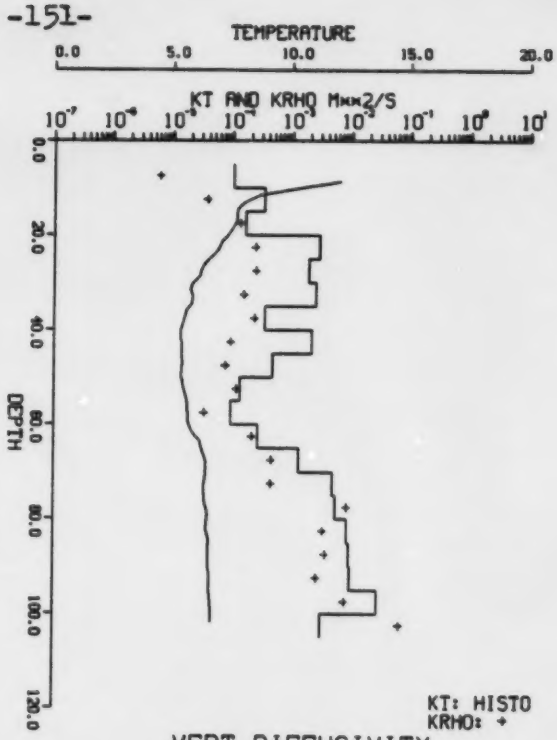
FIGURE 19: Profiles of microstructure quantities for stations 93 to 99 for anchor station 5A23.
- Each page contains a profile of a microstructure quantity averaged over 5 m vertical bins overlaid on a profile of temperature.
- The upper left panel is Chi-Theta, the dissipation of temperature variance.
- The upper right panel contains profiles of vertical diffusivity KT (for temperature) and KRHO for density.
- The lower left panel contains a profile of dissipation, EPSILON.
- The lower right panel shows the profile for Cox number.

The stations are shown in the following order:

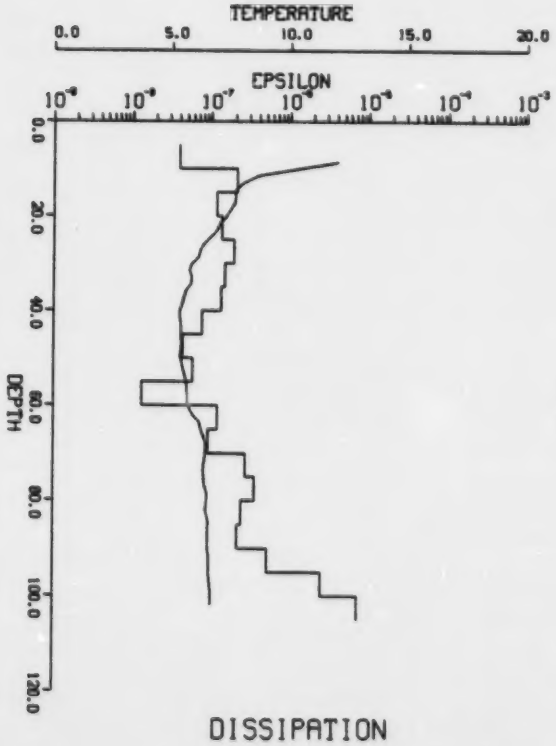
A. Station 93
B. Station 94
C. Station 95
D. Station 96
E. Station 97
F. Station 98
G. Station 99



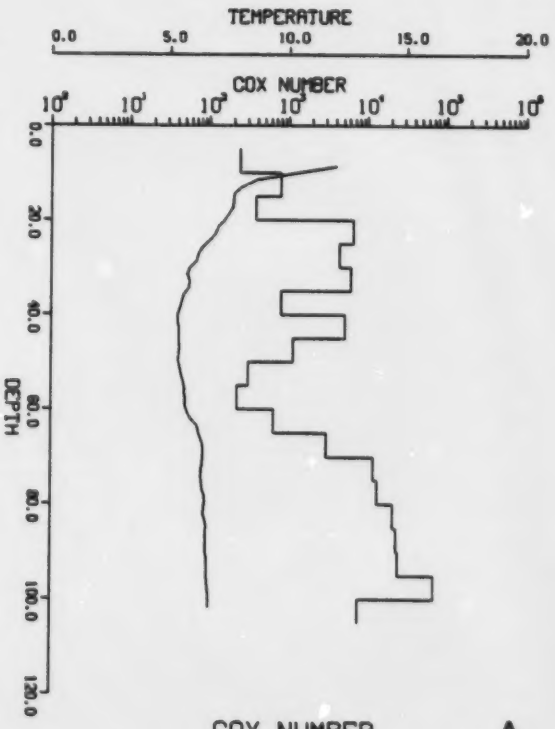

88023 - 093 CHI-THETA



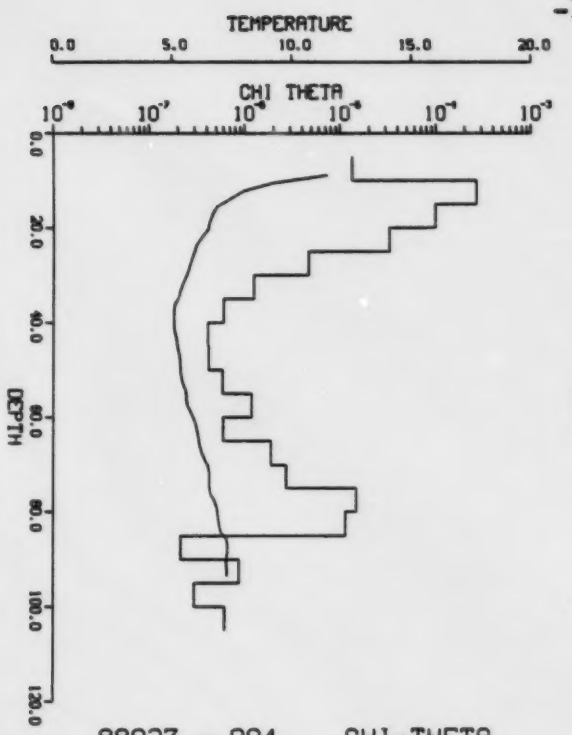

VERT DIFFUSIVITY



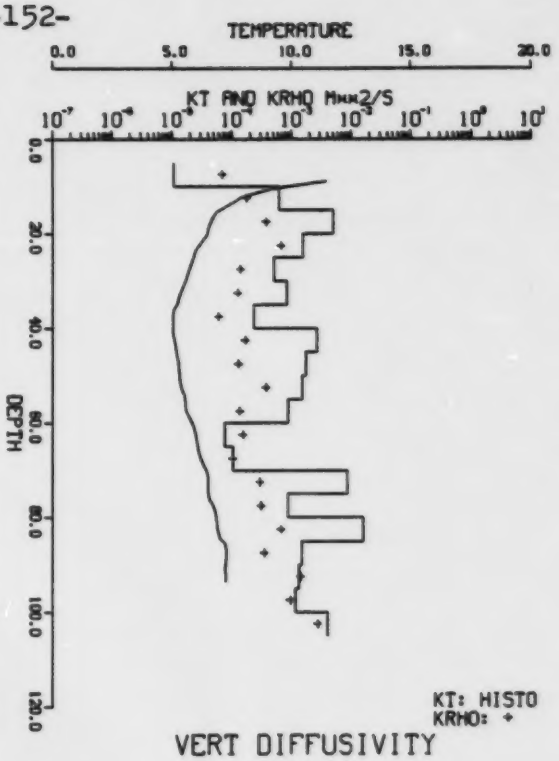

DISSIPATION



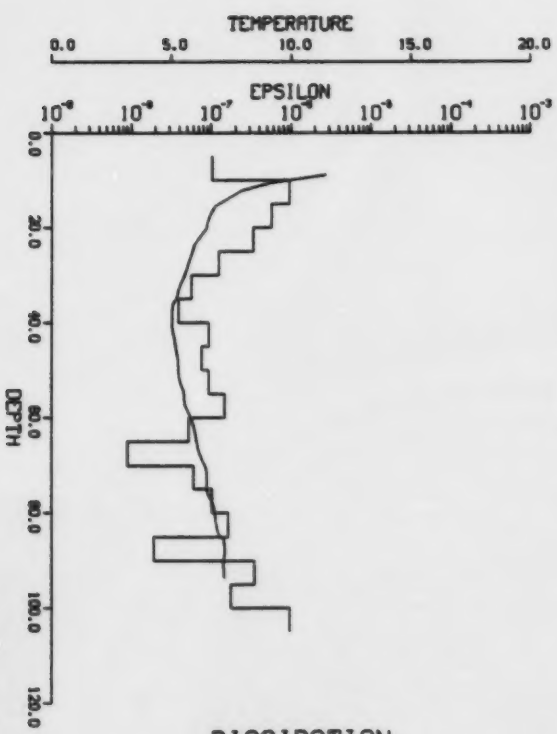

COX NUMBER A




88023 - 094 CHI-THETA

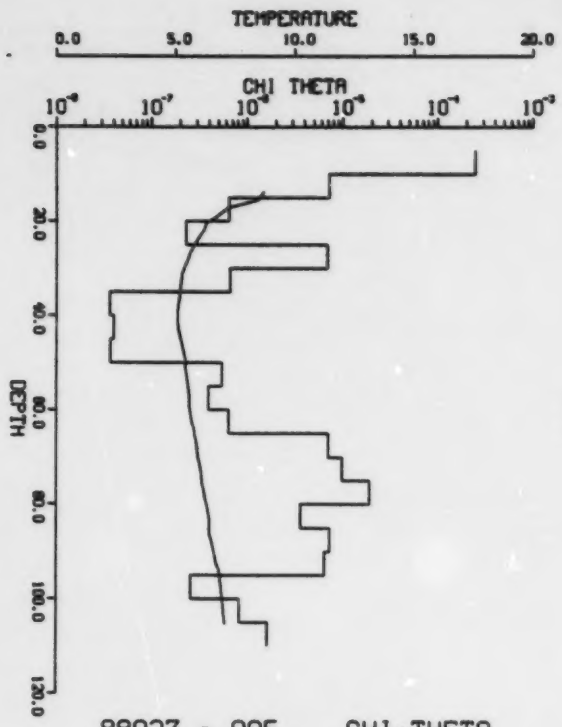



VERT DIFFUSIVITY

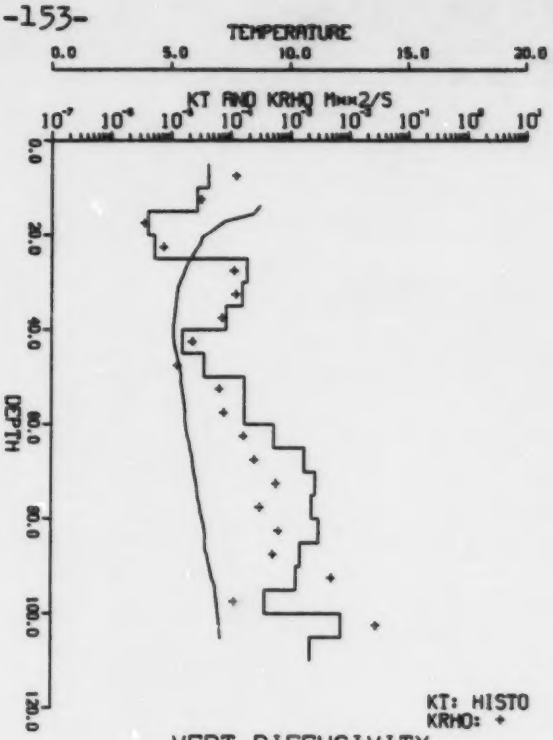



DISSIPATION

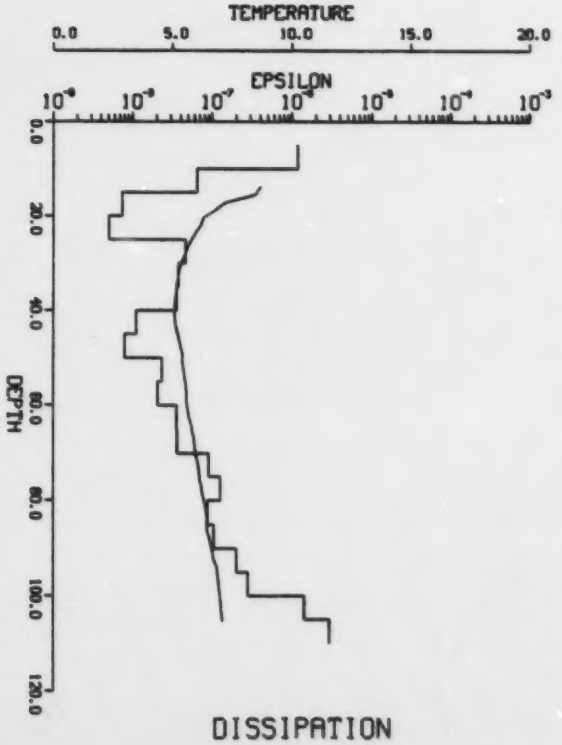
COX NUMBER B



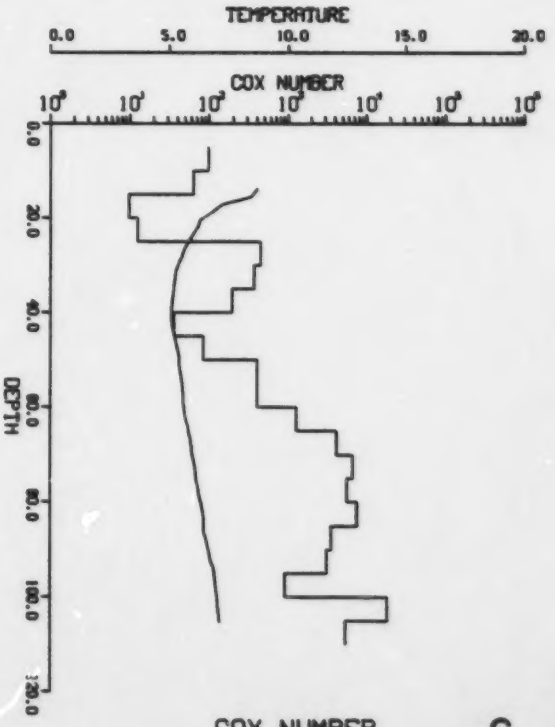

88023 - 095 CHI-THETA



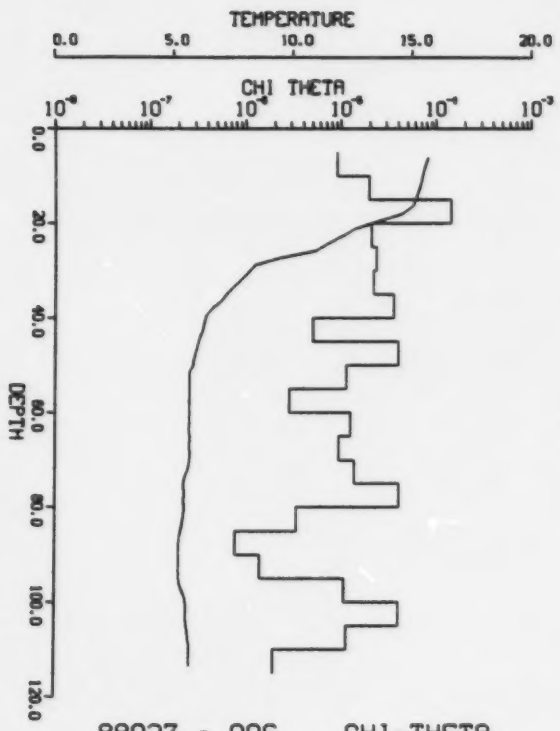

VERT DIFFUSIVITY



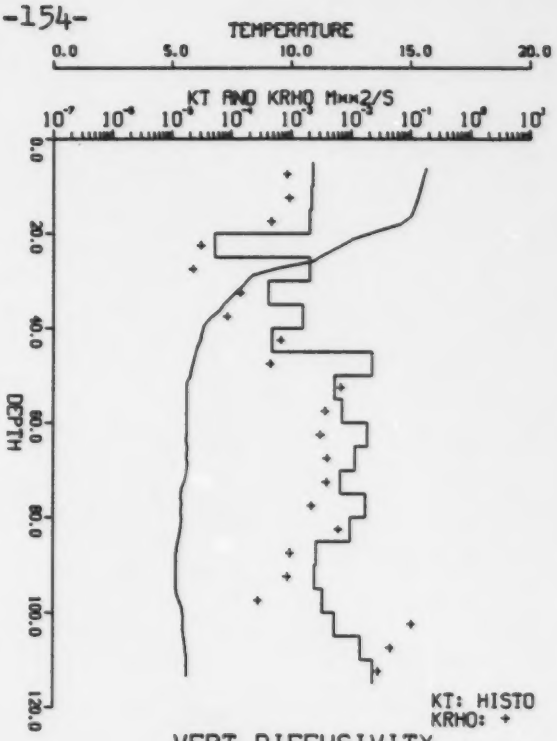

DISSIPATION



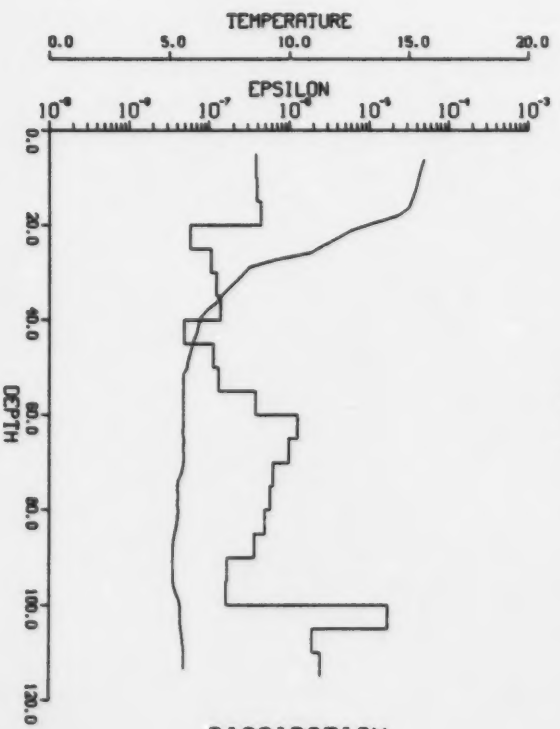

COX NUMBER C



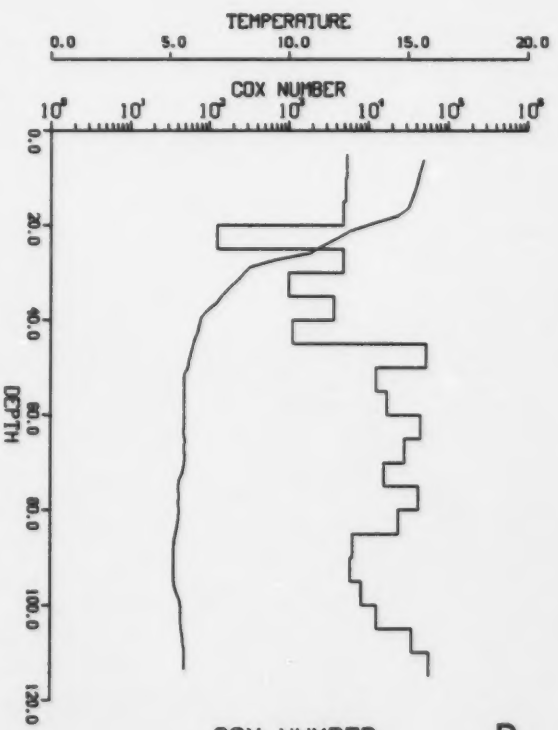

88023 - 096 CHI-THETA




VERT DIFFUSIVITY

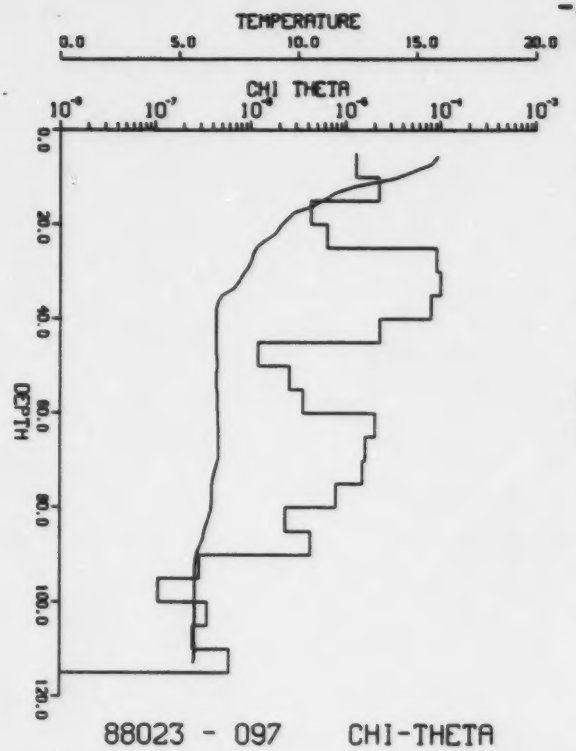



DISSIPATION

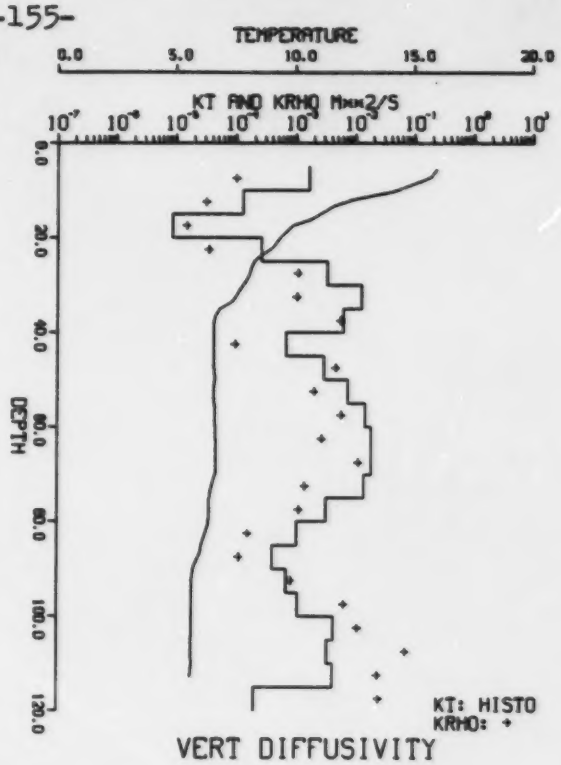



COX NUMBER

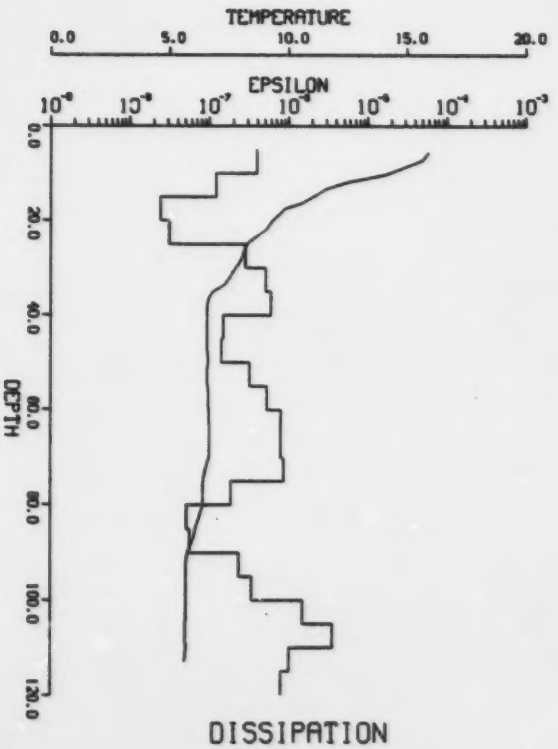
D




88023 - 097 CHI-THETA




VERT DIFFUSIVITY

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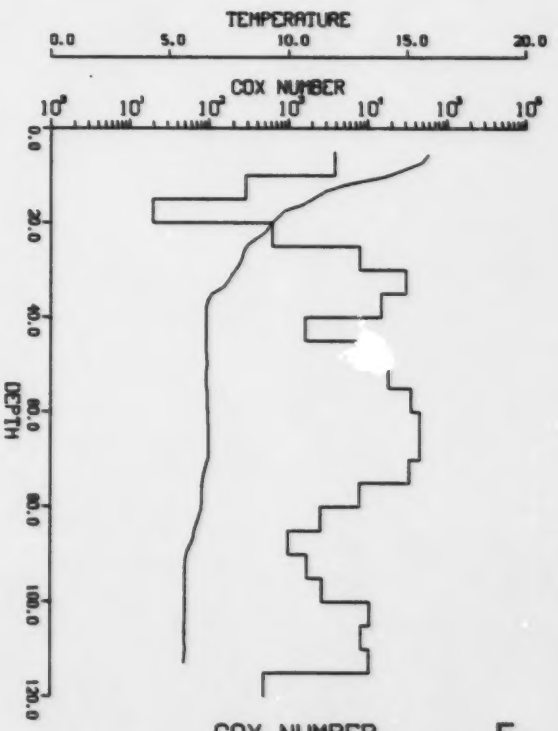
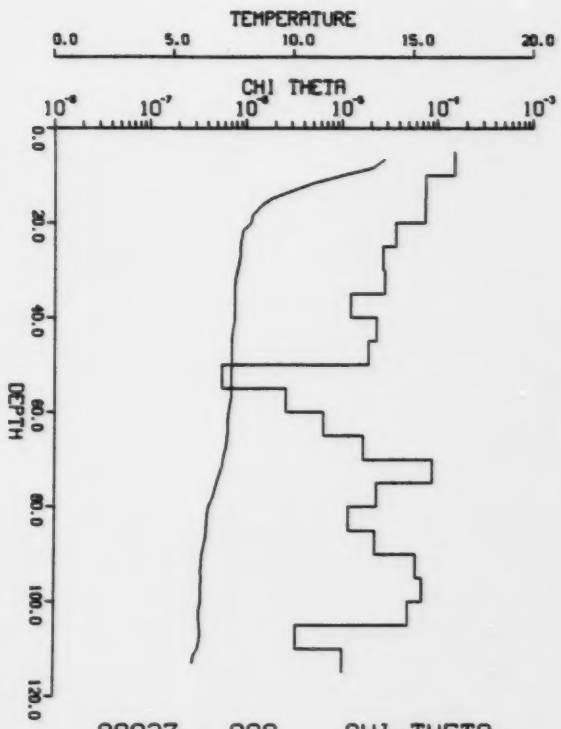
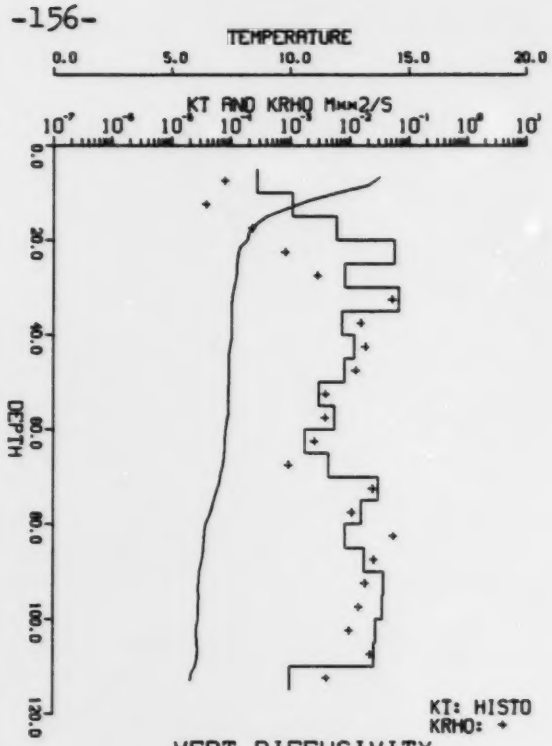


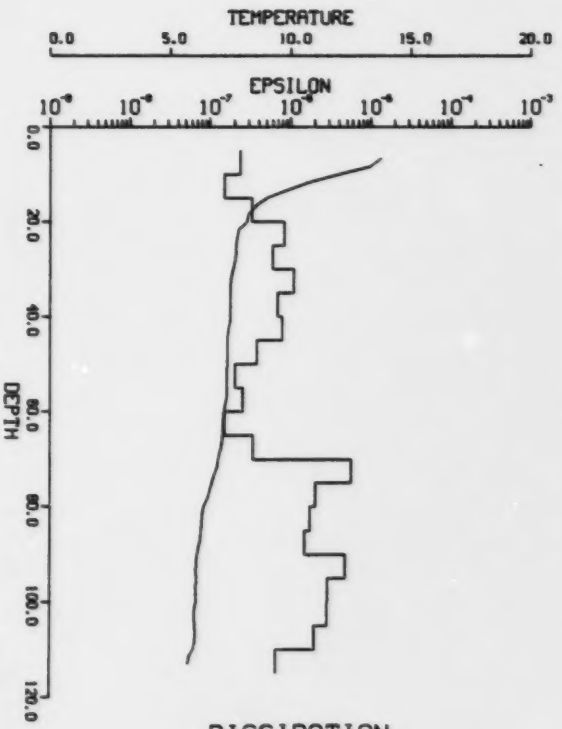

COX NUMBER E



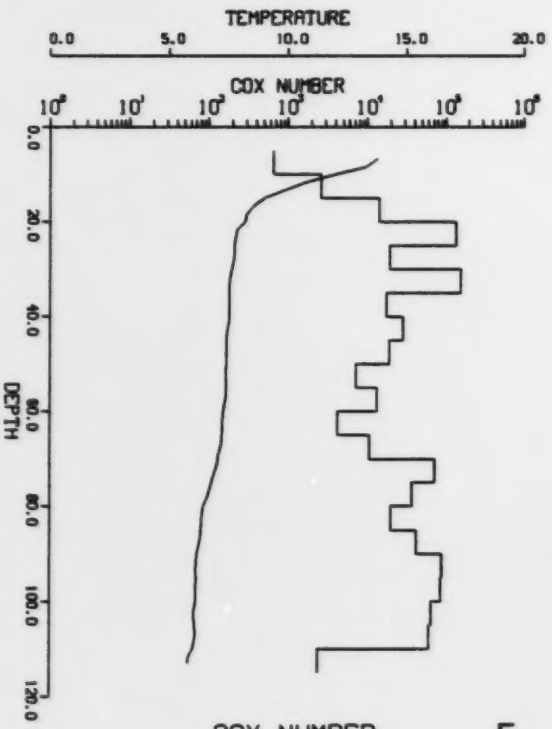

88023 - 098 CHI-THETA



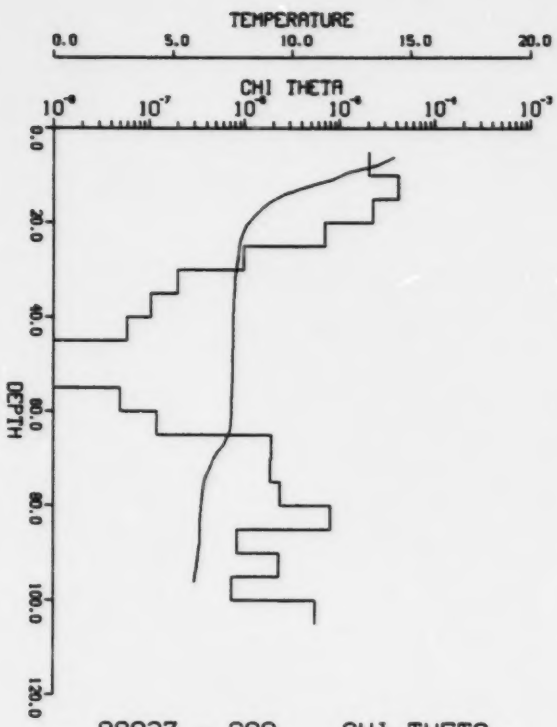

VERT DIFFUSIVITY



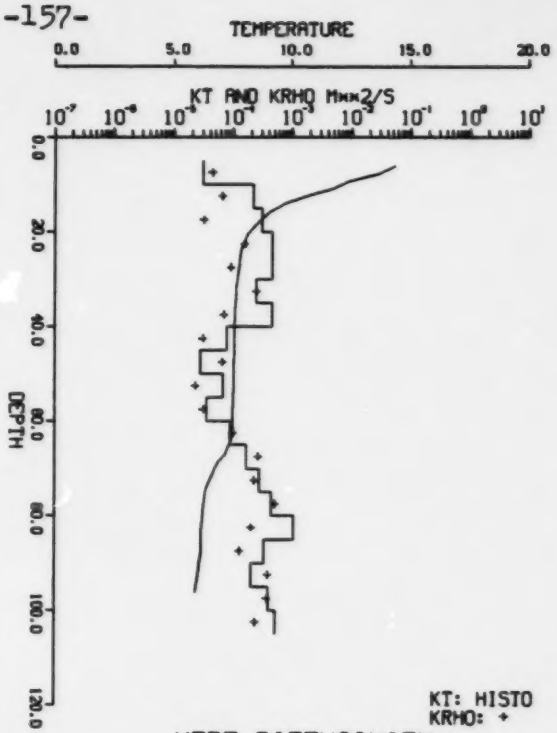

DISSIPATION



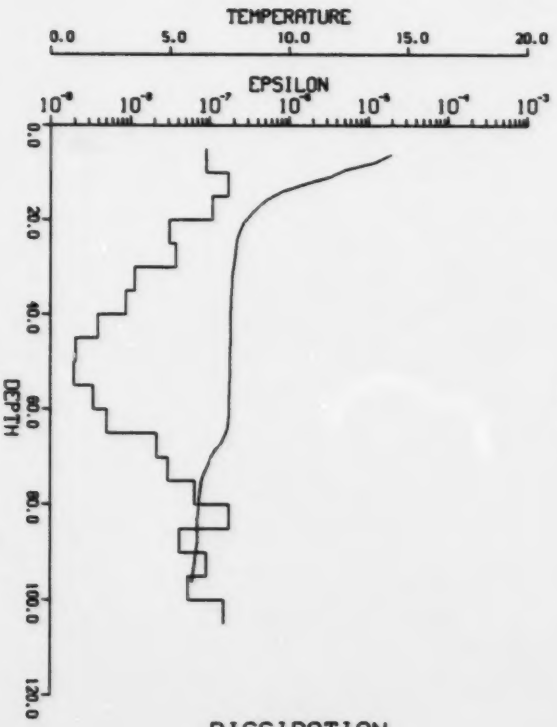

COX NUMBER F



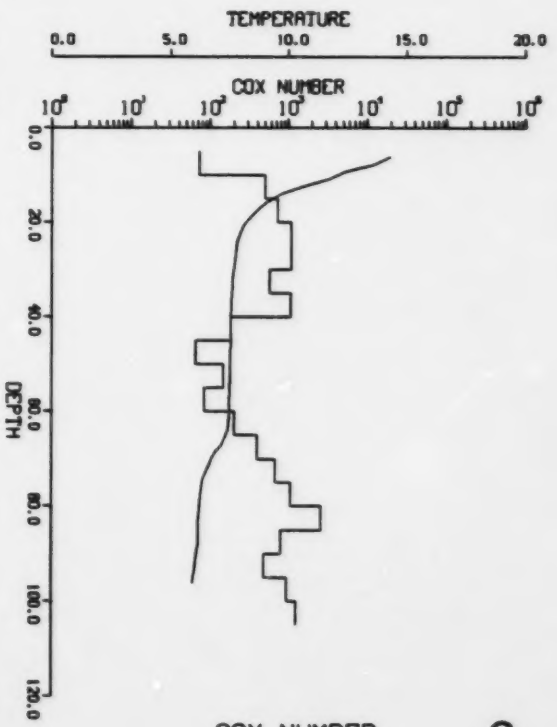

88023 - 099 CHI-THETA




VERT DIFFUSIVITY




DISSIPATION




COX NUMBER

G

# SITE 6A23

41°58.65N, 66°28.98W

TABLE 9: COMBINED CURRENT AND DISSIPATION

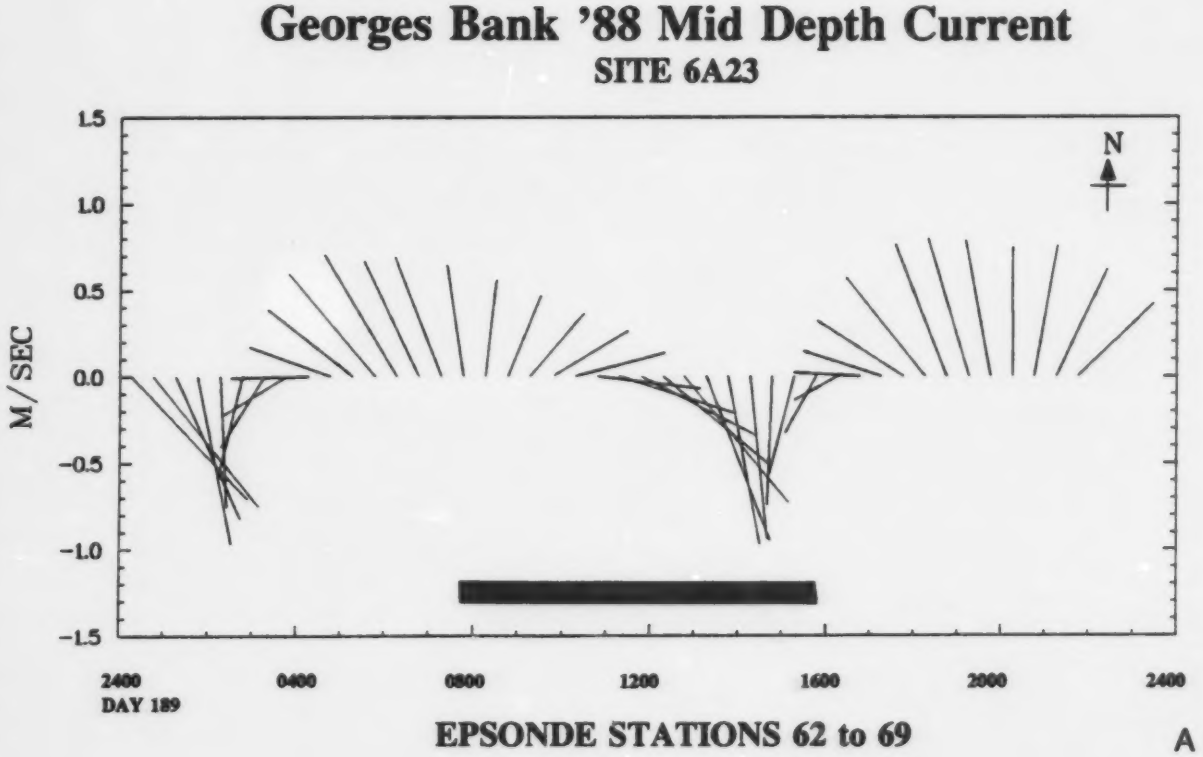
| Station | TimeEPS | Depth | Drops | Current | IntEPS | ErrEPS |
|---|---|---|---|---|---|---|
| E62 | 189.3281 | 77.30 | 8 | 0.590 | 0.0526 | 0.0060 |
| E63 | 189.3715 | 75.50 | 8 | 0.453 | 0.0302 | 0.0035 |
| E64 | 189.4118 | 74.95 | 8 | 0.429 | 0.0111 | 0.0009 |
| E65 | 189.4566 | 74.30 | 8 | 0.564 | 0.0538 | 0.0695 |
| E66 | 189.5028 | 74.55 | 8 | 0.717 | 0.0461 | 0.0109 |
| E67 | 189.5521 | 71.20 | 8 | 0.753 | 0.0568 | 0.0080 |
| E68 | 189.5976 | 73.25 | 8 | 0.647 | 0.0977 | 0.0157 |
| E69 | 189.6476 | 75.35 | 10 | 0.403 | 0.0711 | 0.0081 |

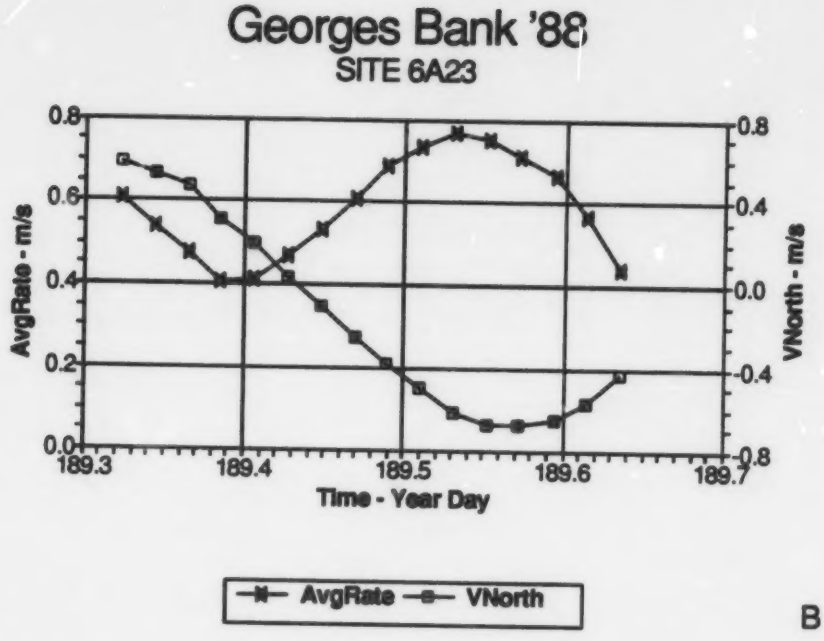
FIGURE 20:

A. Current vector plot for the RCM at 41m depth at site 6 overlapping the EPSONDE anchor station 6A during cruise 88023 (6A23). This anchor station includes EPSONDE stations 62 to 69.

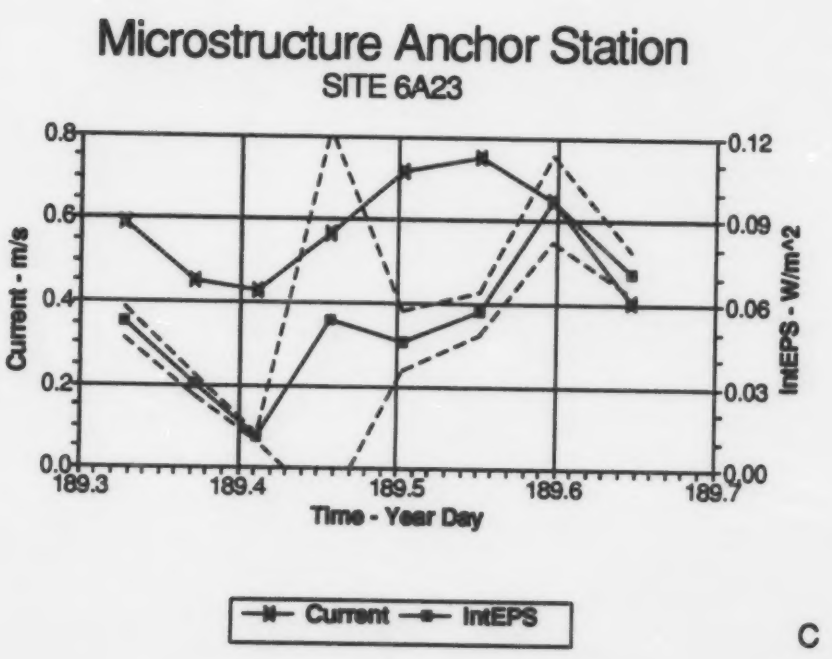
B. The magnitude and the northward component of the vertically averaged composite RCM and Ametek DCP current at half hourly intervals for site 6 coincident with EPSONDE anchor station 6A23.

C. The magnitude of the vertically averaged composite current interpolated to the mean EPSONDE station time and the integrated dissipation, IntEPS, for each EPSONDE station during anchor station 6A23. Error limits are indicated for IntEPS.




Georges Bank '88
SITE 6A23
AvgRate - m/s
VNorth - m/s
Time - Year Day
0.8
0.6
0.4
0.2
0.0
-0.4
-0.8
189.3
189.4
189.5
189.6
189.7
AvgRate
VNorth

B


Microstructure Anchor Station
SITE 6A23
Current - m/s
IntEPS - W/m^2
Time - Year Day
0.8
0.6
0.4
0.2
0.0
0.12
0.09
0.06
0.03
0.00
189.3
189.4
189.5
189.6
189.7
Current
IntEPS

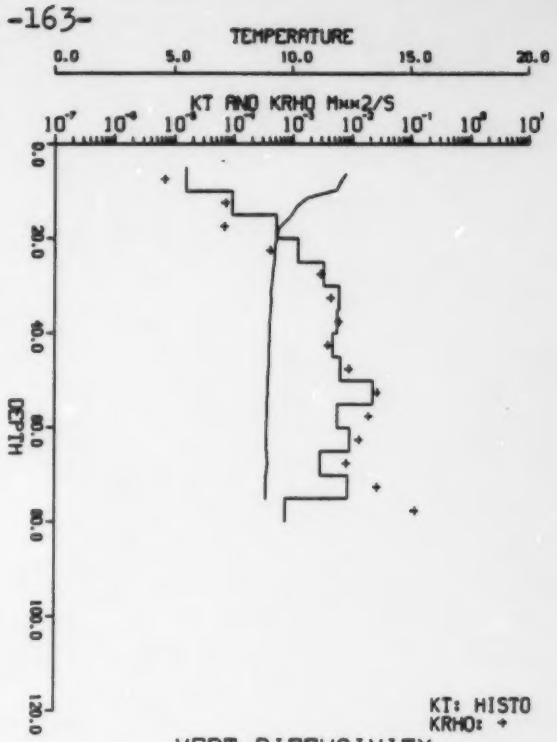
C

FIGURE 21: Profiles of microstructure quantities for stations 62 to 69 for anchor station 6A23.
- Each page contains a profile of a microstructure quantity averaged over 5 m vertical bins overlaid on a profile of temperature.
- The upper left panel is Chi-Theta, the dissipation of temperature variance.
- The upper right panel contains profiles of vertical diffusivity KT (for temperature) and KHRO for density.
- The lower left panel contains a profile of dissipation, EPSILON.
- The lower right panel shows the profile for Cox number.

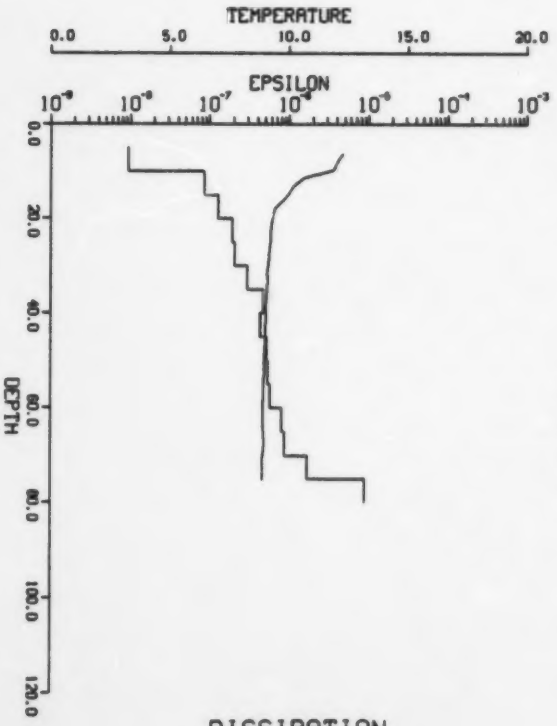
The stations are shown in the following order:

A. Station 62
B. Station 63
C. Station 64
D. Station 65
E. Station 66
F. Station 67
G. Station 68
H. Station 69

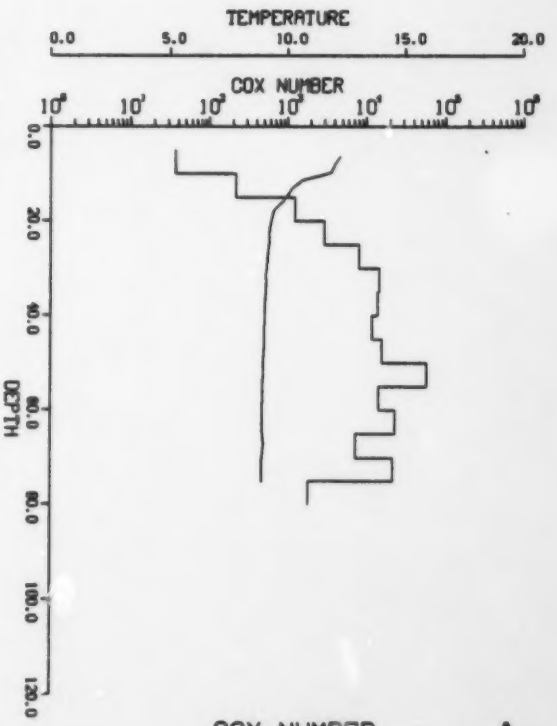
88023 - 062 CHI-THETA



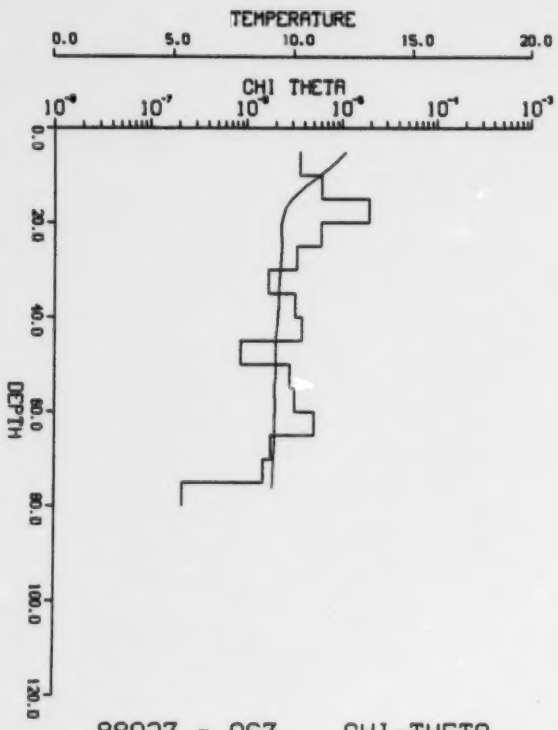

VERT DIFFUSIVITY



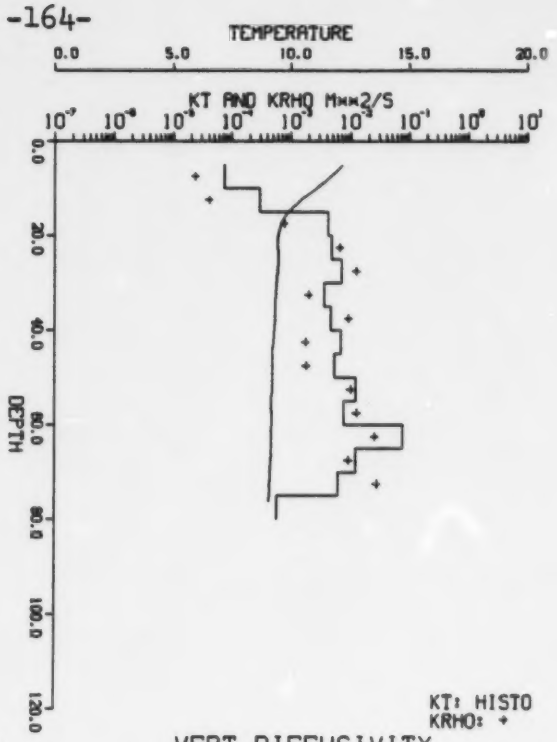

DISSIPATION



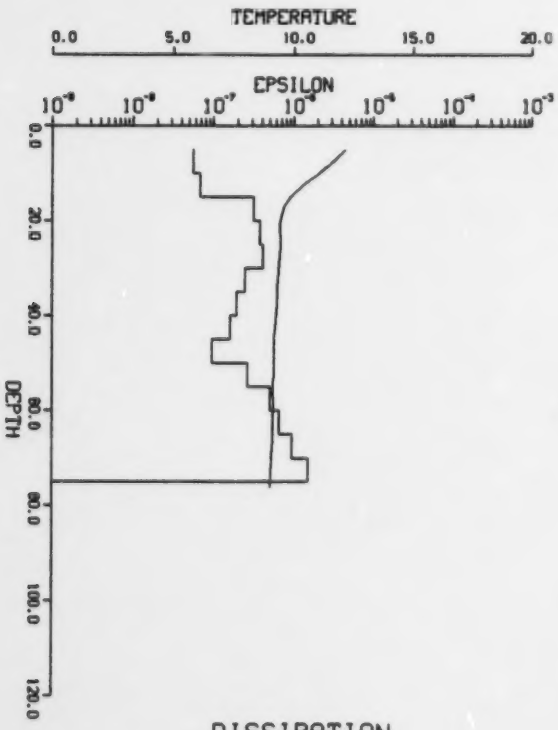

COX NUMBER A



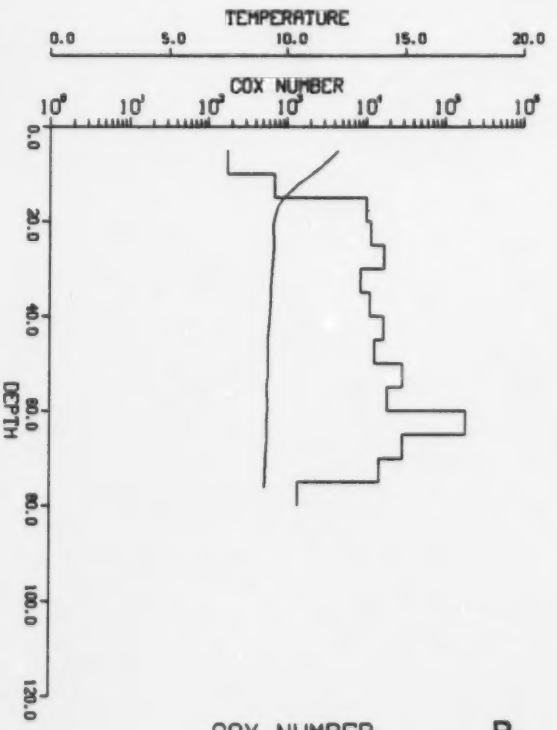

88023 - 063 CHI-THETA



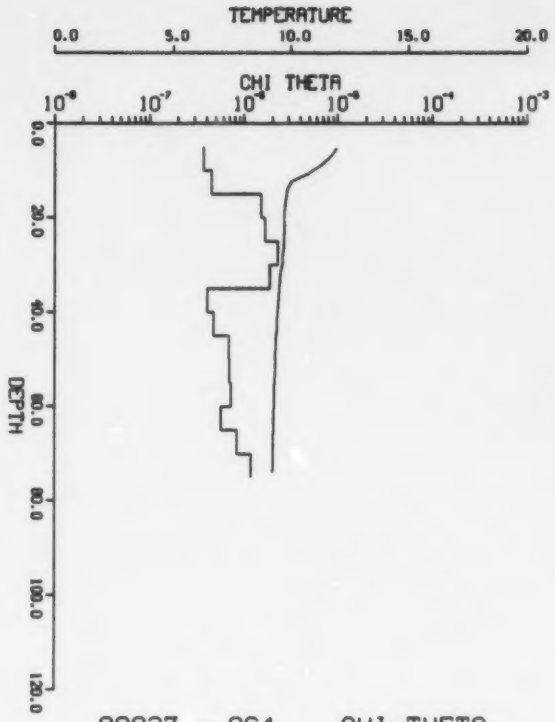

VERT DIFFUSIVITY



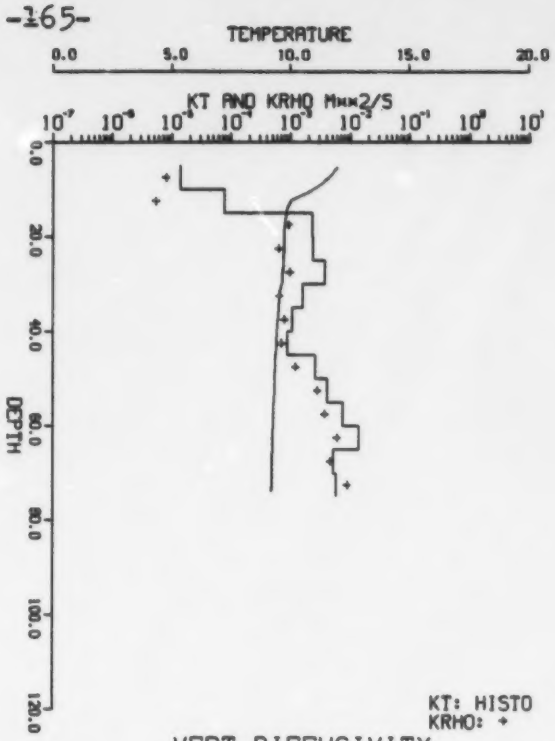

DISSIPATION



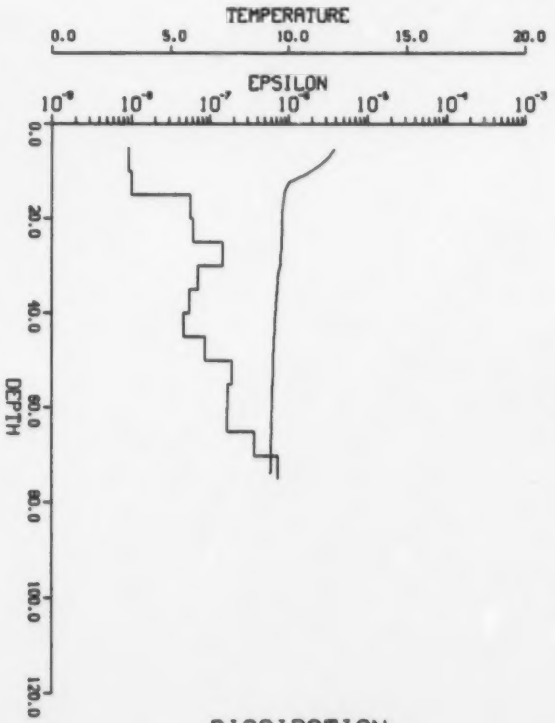

COX NUMBER B



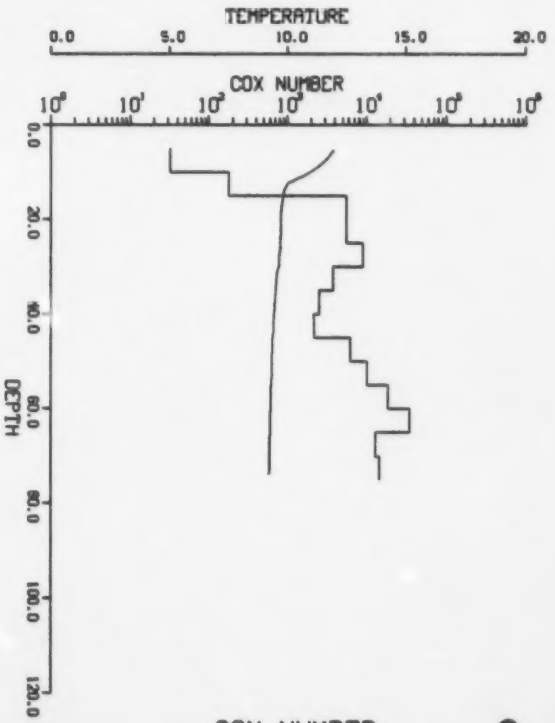

88023 - 064 CHI-THETA



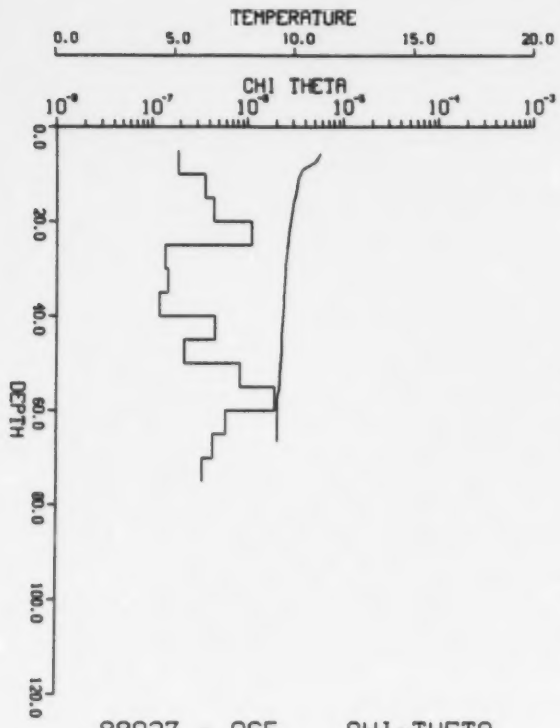

VERT DIFFUSIVITY



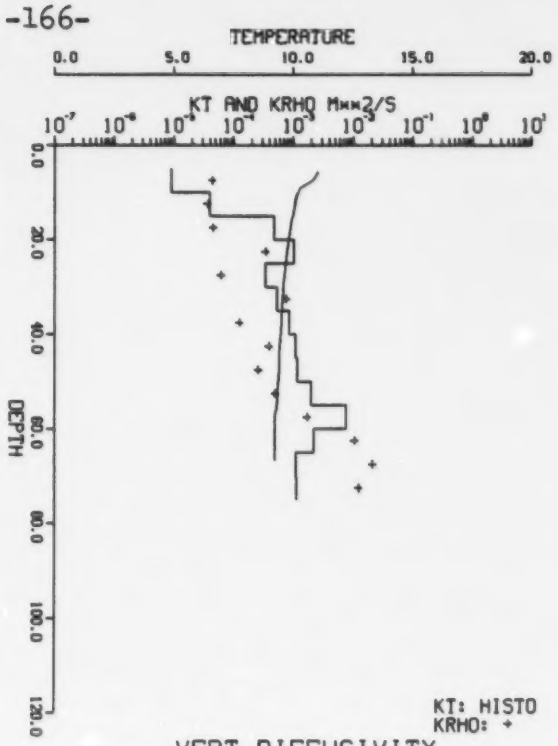

DISSIPATION



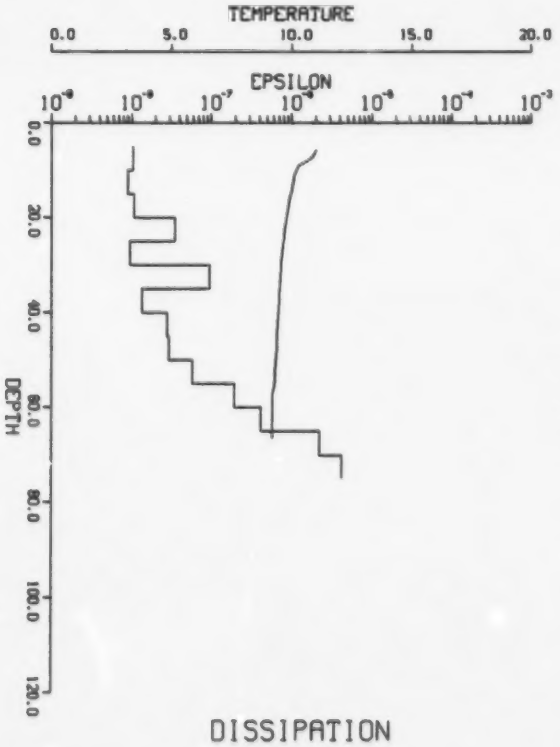

COX NUMBER C



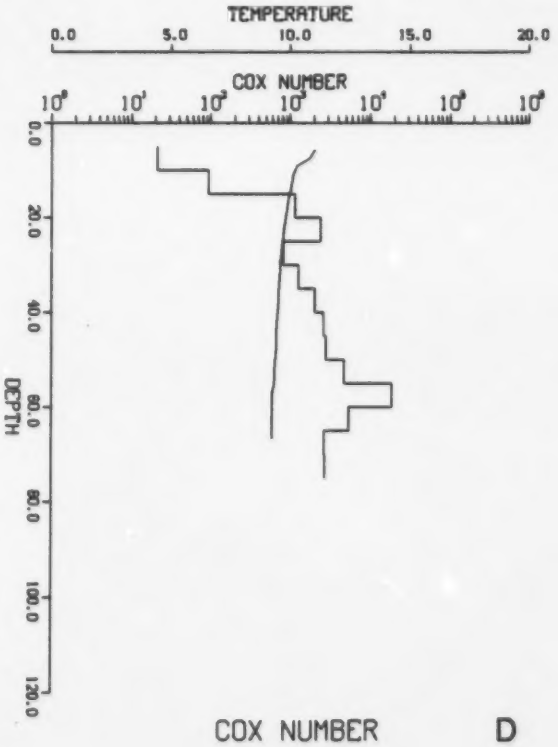

88023 - 065 CHI-THETA



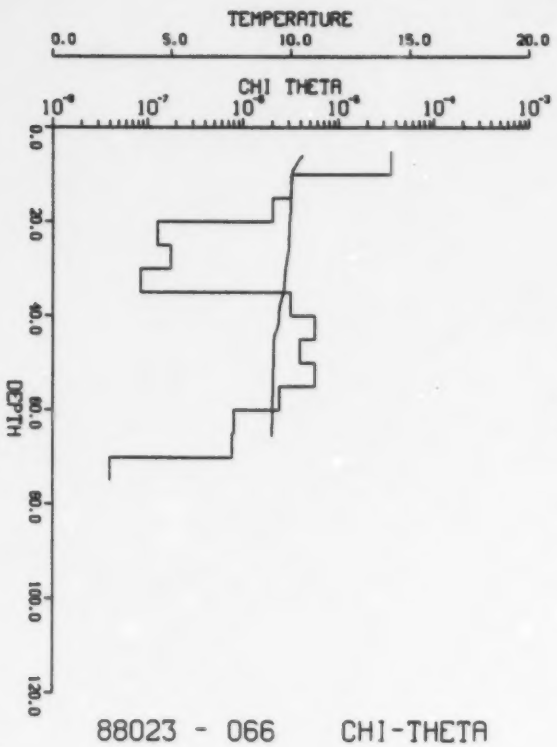

VERT DIFFUSIVITY



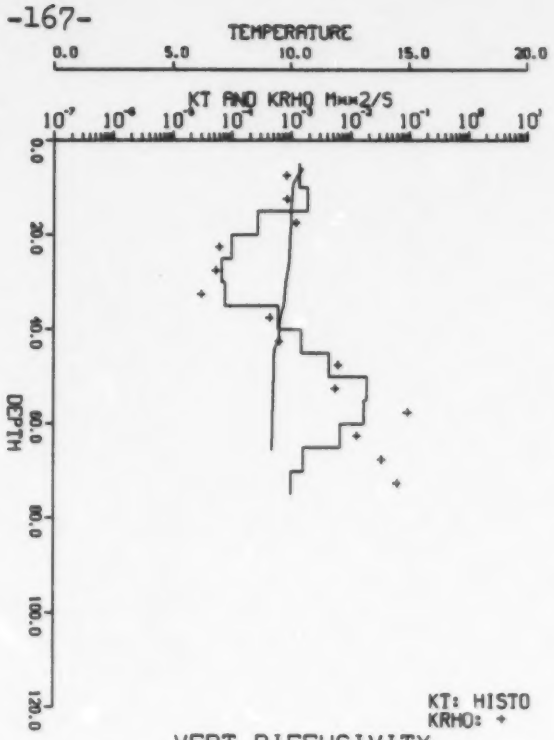

DISSIPATION



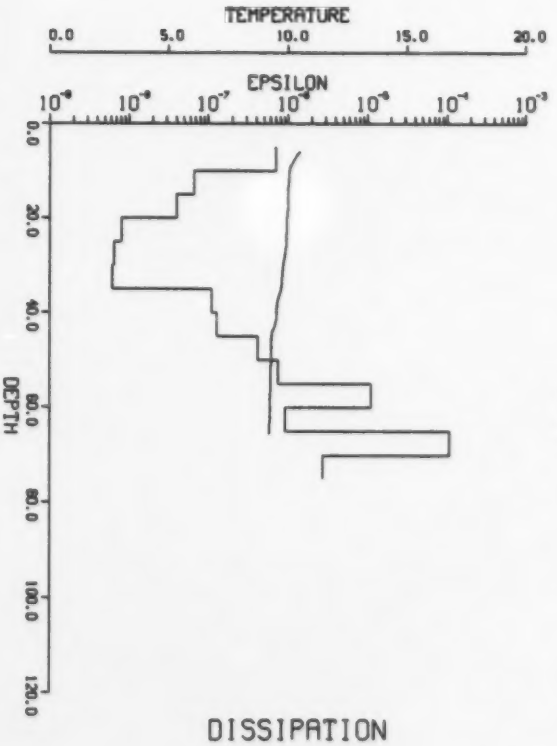

COX NUMBER D



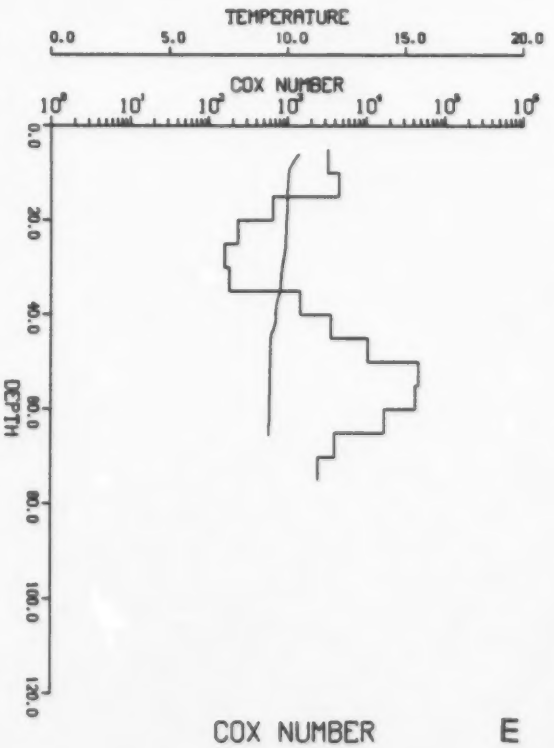

88023 - 066 CHI-THETA



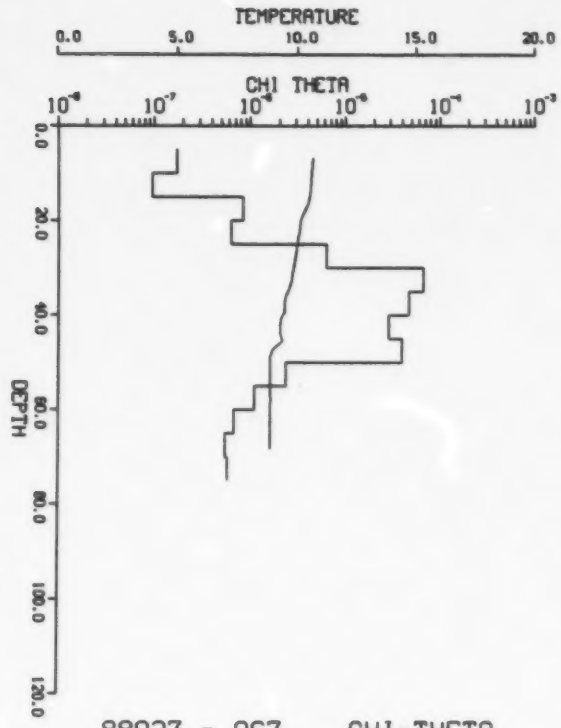

VERT DIFFUSIVITY



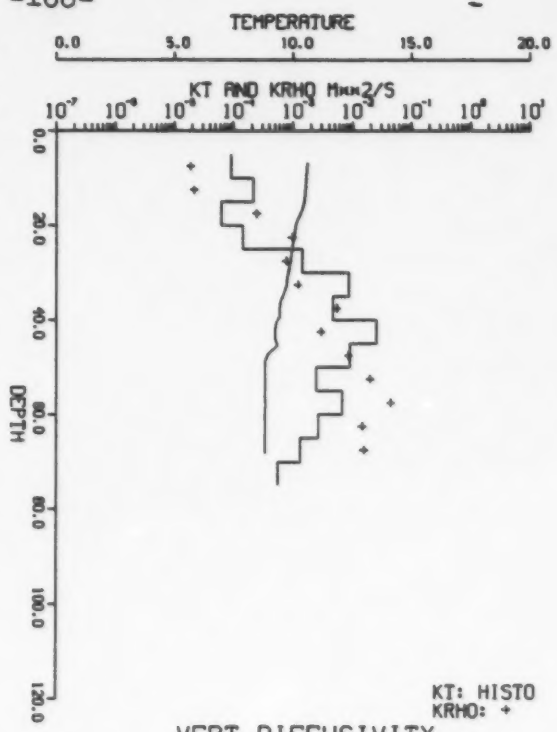

DISSIPATION



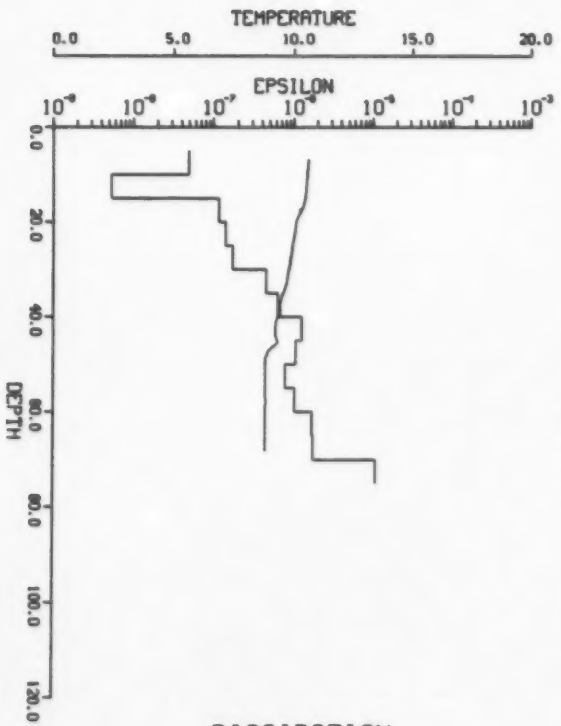

COX NUMBER E



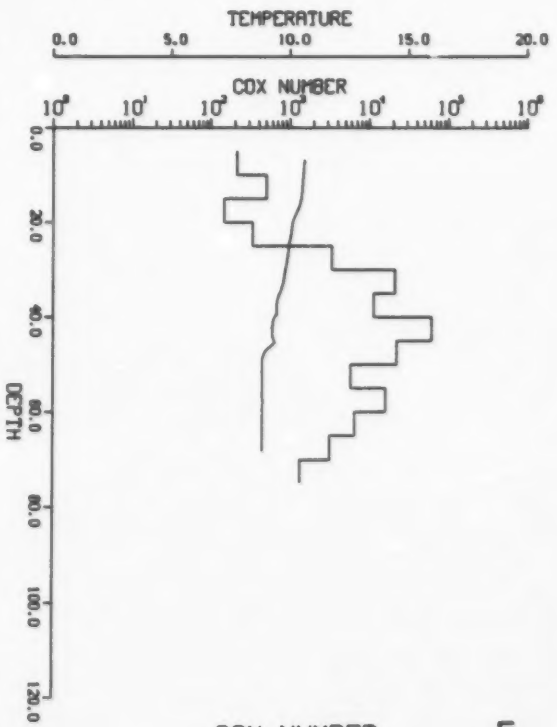

88023 - 067 CHI-THETA




VERT DIFFUSIVITY

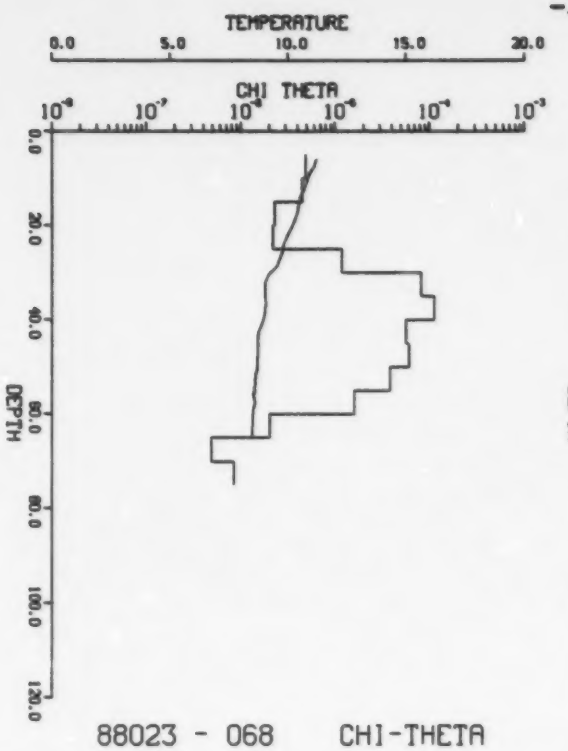



DISSIPATION

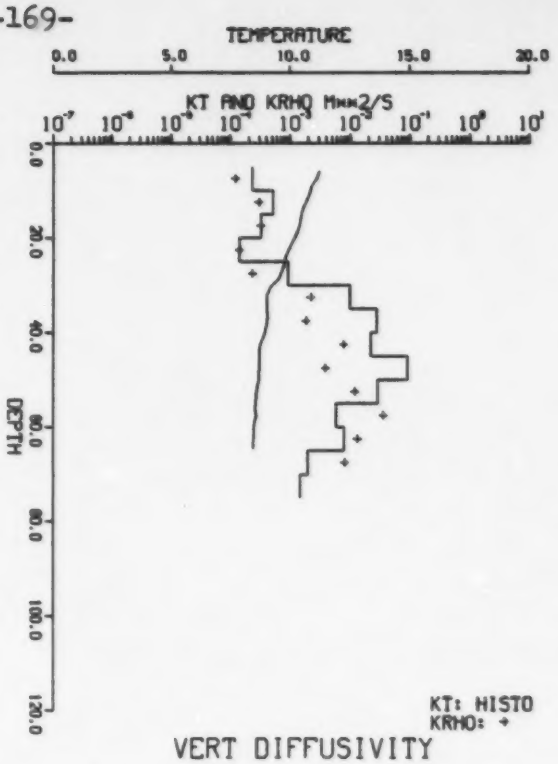



COX NUMBER

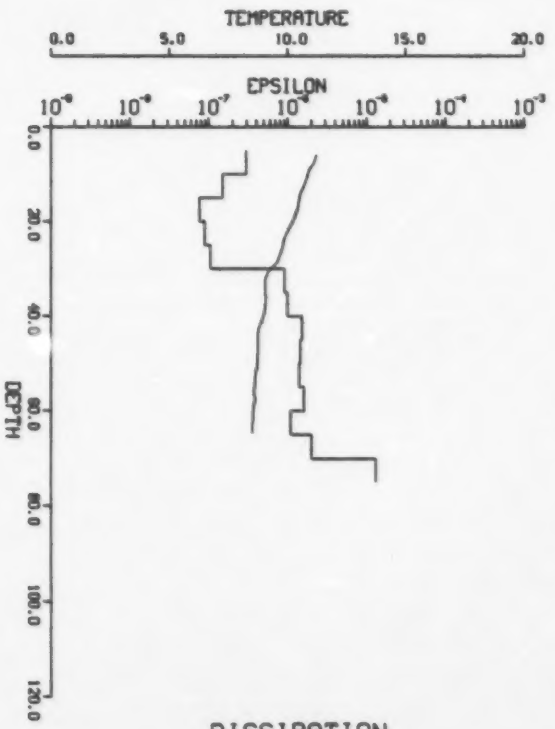
F



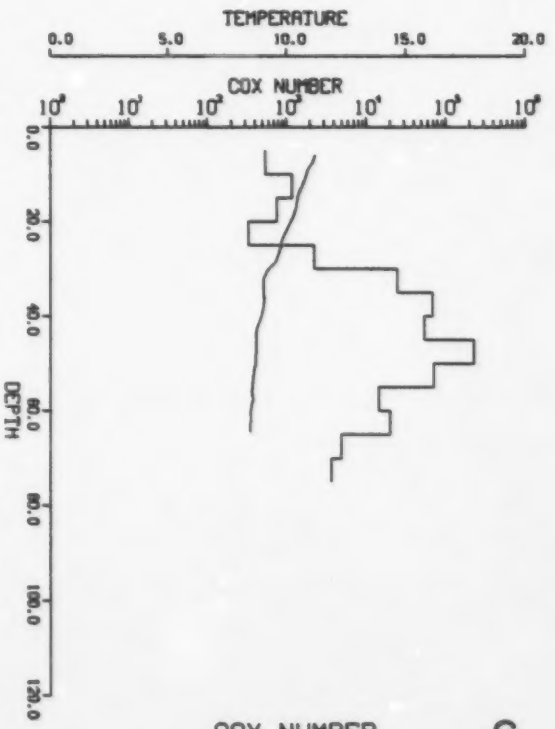

88023 - 068 CHI-THETA



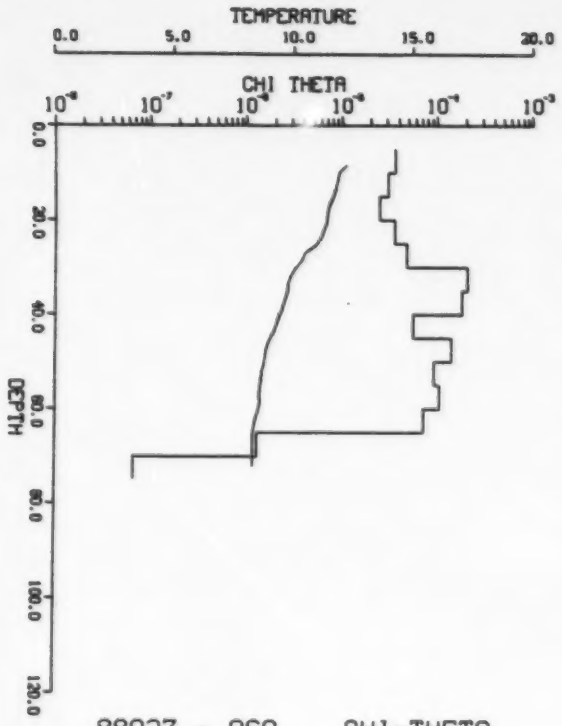

VERT DIFFUSIVITY



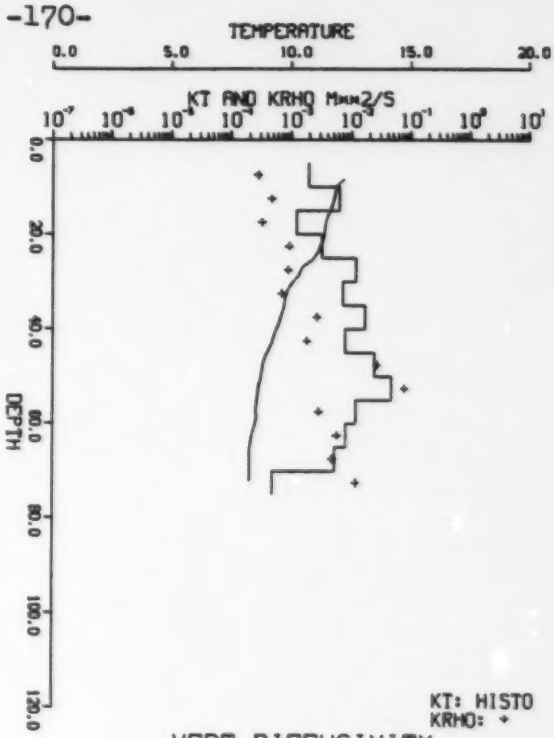

DISSIPATION



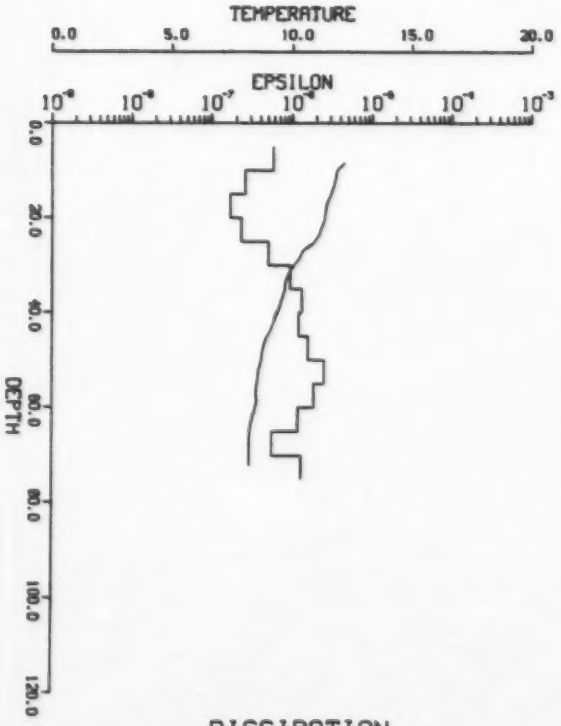

COX NUMBER G



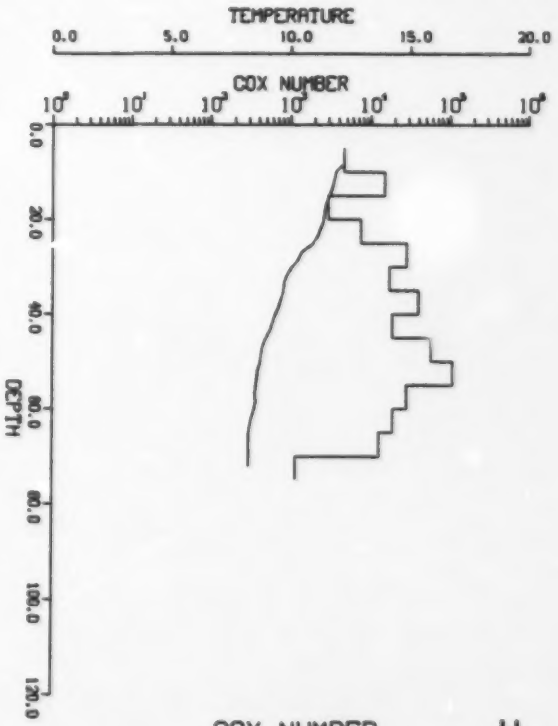

88023 - 069 CHI-THETA




VERT DIFFUSIVITY




DISSIPATION




COX NUMBER H

# SITE 1A36

42°08.82N, 66°47.72W

TABLE 10: COMBINED CURRENT AND DISSIPATION

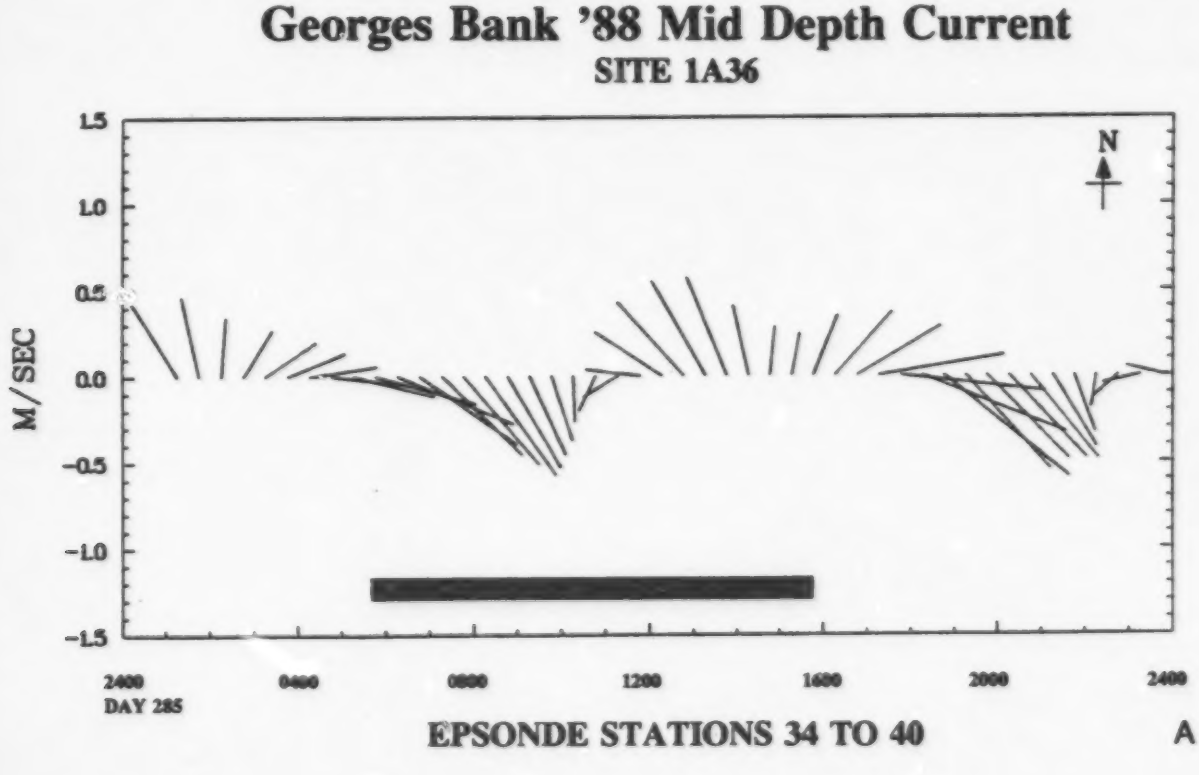
| Station | TimeEPS | Depth | Drops | Current | IntEPS | ErrEPS |
|---|---|---|---|---|---|---|
| E234 | 285.2486 | 10[illegible]5 | 8 | 0.442 | 0.0173 | 0.0027 |
| E235 | 285.3139 | 99.05 | 8 | 0.448 | 0.0164 | 0.0039 |
| E236 | 285.3726 | 100.90 | 7 | 0.241 | 0.0191 | 0.0022 |
| E237 | 285.4153 | 96.20 | 1 | 0.068 | 0.0413 | 0.0110 |
| E238 | 285.5323 | 102.05 | 8 | 0.528 | 0.0284 | 0.0047 |
| E239 | 285.5917 | 105.60 | 8 | 0.388 | 0.0332 | 0.0109 |
| E240 | 285.6469 | 104.20 | 7 | 0.230 | 0.1071 | 0.0443 |

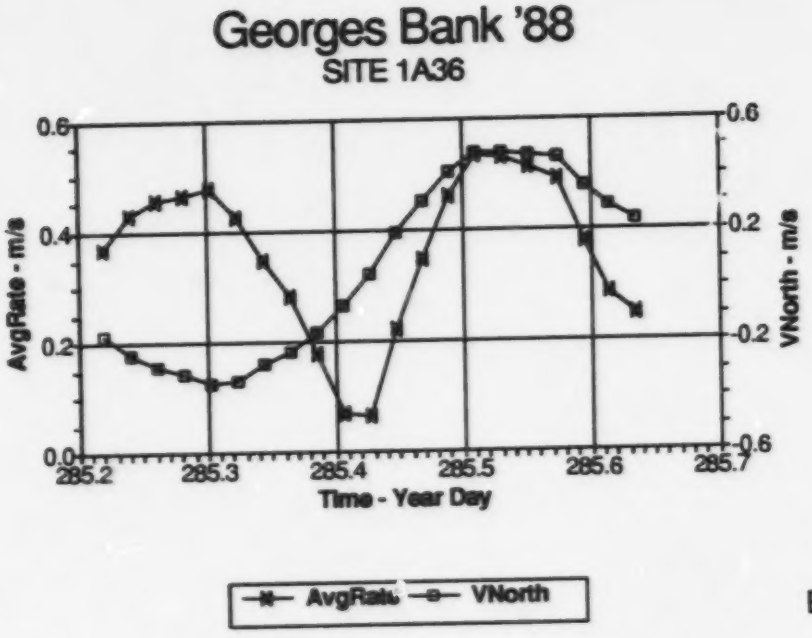
FIGURE 22:

A. Current vector plot for the RCM at 43m depth at site 1 overlapping the EPSONDE anchor station 1A during cruise 88036 (1A36). This anchor station includes EPSONDE stations 234 to 240.

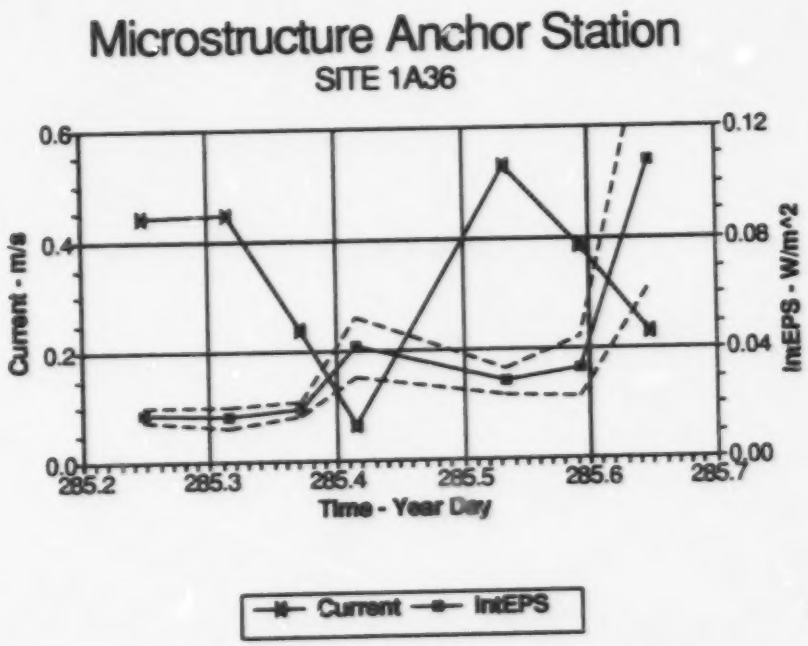
B. The magnitude and the northward component of the vertically averaged composite RCM and Ametek DCP current at half hourly intervals for site 1 coincident with EPSONDE anchor station 1A36.

C. The magnitude of the vertically averaged composite current interpolated to the mean EPSONDE station time and the integrated dissipation, IntEPS, for each EPSONDE station during anchor station 1A36. Error limits are indicated for IntEPS.




Georges Bank '88
SITE 1A36
AvgRate - m/s
VNorth - m/s
Time - Year Day
0.6
0.4
0.2
0.0
-0.2
-0.6
285.2
285.3
285.4
285.5
285.6
285.7
AvgRate
VNorth

B

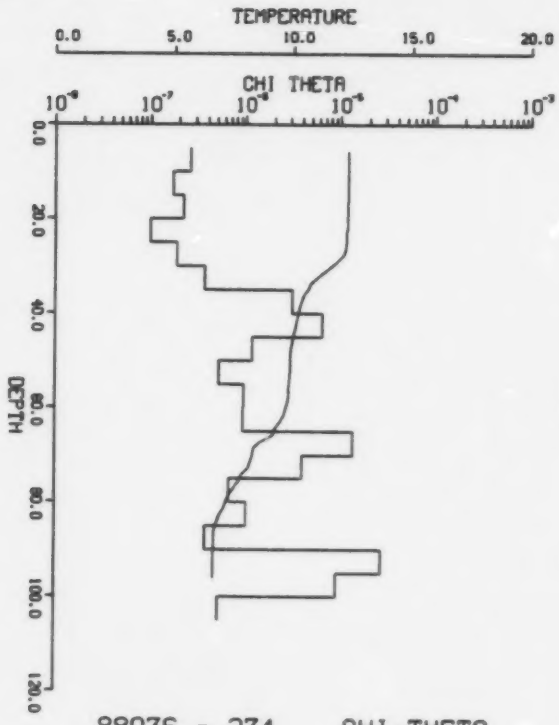

Microstructure Anchor Station
SITE 1A36
Current - m/s
IntEPS - W/m^2
Time - Year Day
0.6
0.4
0.2
0.0
0.12
0.08
0.04
0.00
285.2
285.3
285.4
285.5
285.6
285.7
Current
IntEPS

C

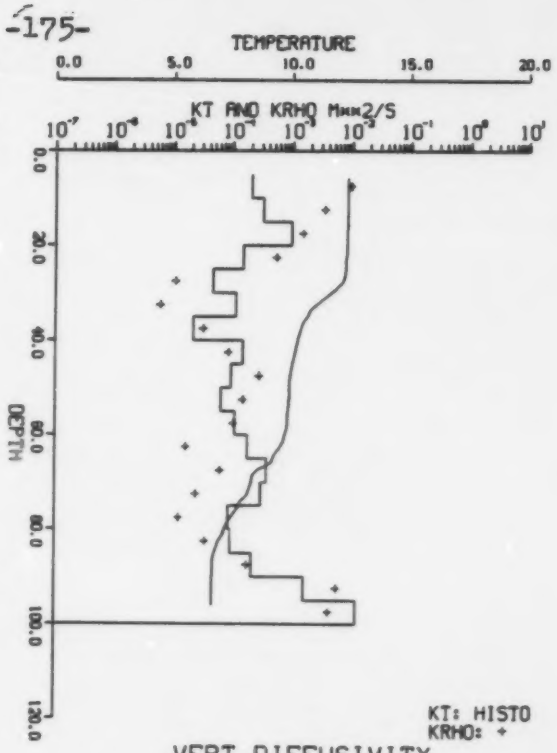
FIGURE 23: Profiles of microstructure quantities for stations 234 to 240 for anchor station 1A36.
- Each page contains a profile of a microstructure quantity averaged over 5 m vertical bins overlaid on a profile of temperature.
- The upper left panel is Chi-Theta, the dissipation of temperature variance.
- The upper right panel contains profiles of vertical diffusivity KT (for temperature) and KRHO for density.
- The lower left panel contains a profile of dissipation, EPSILON.
- The lower right panel shows the profile for Cox number.

The stations are shown in the following order:

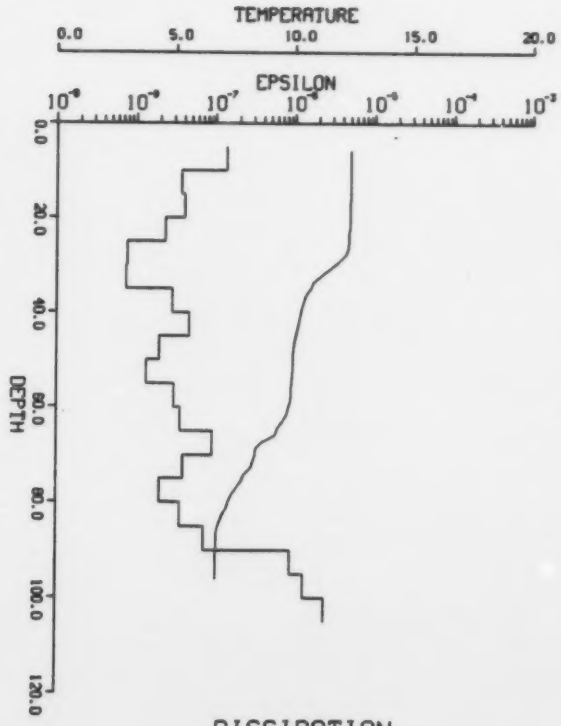
A. Station 234
B. Station 235
C. Station 236
D. Station 237
E. Station 238
F. Station 239
G. Station 240



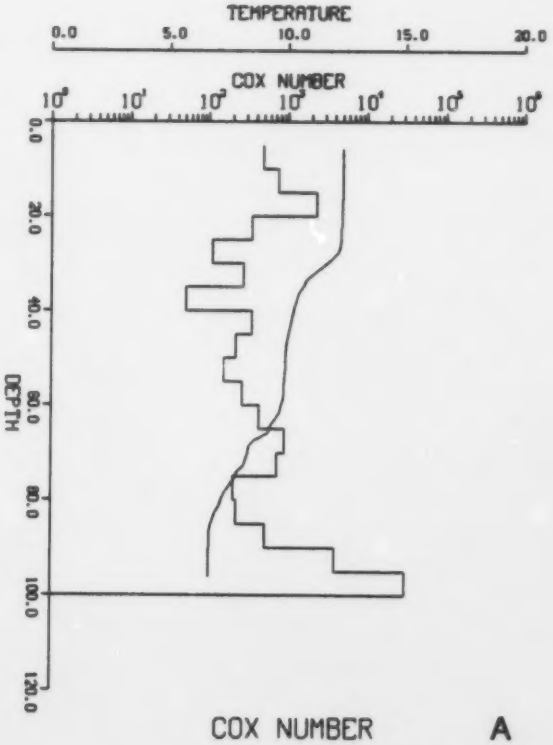

88036 - 234 CHI-THETA



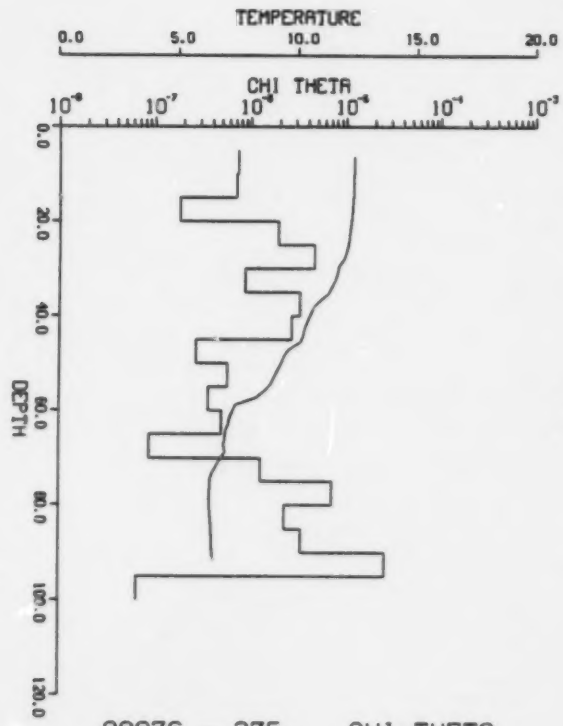

VERT DIFFUSIVITY



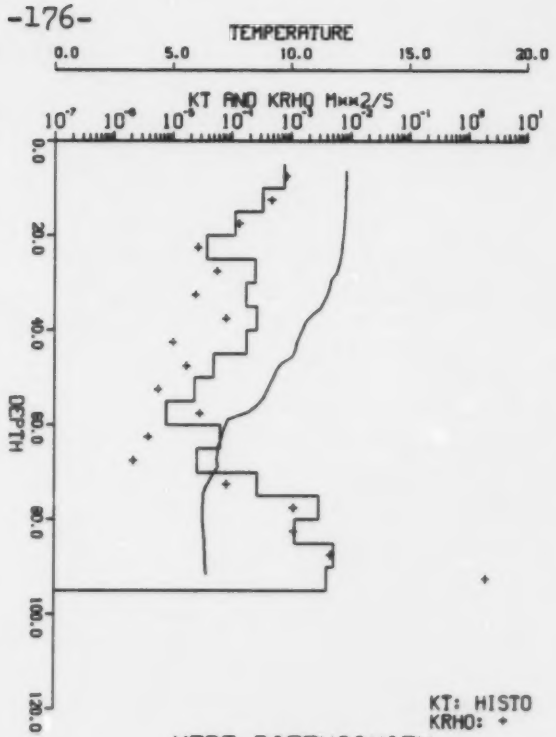

DISSIPATION



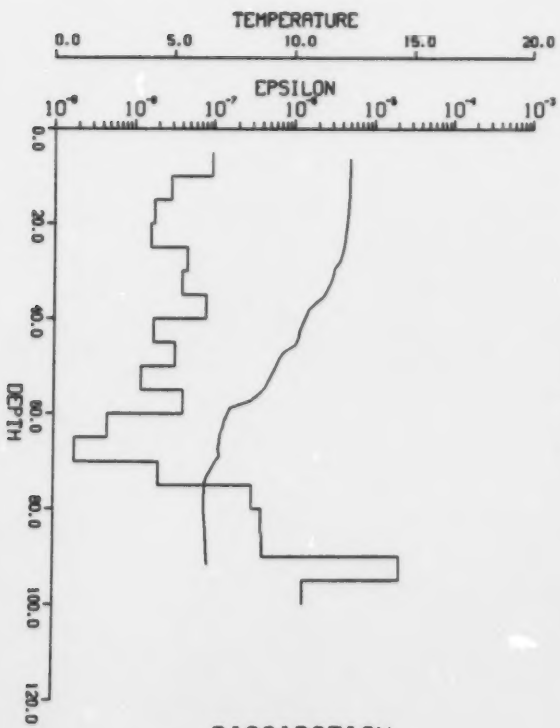

COX NUMBER A



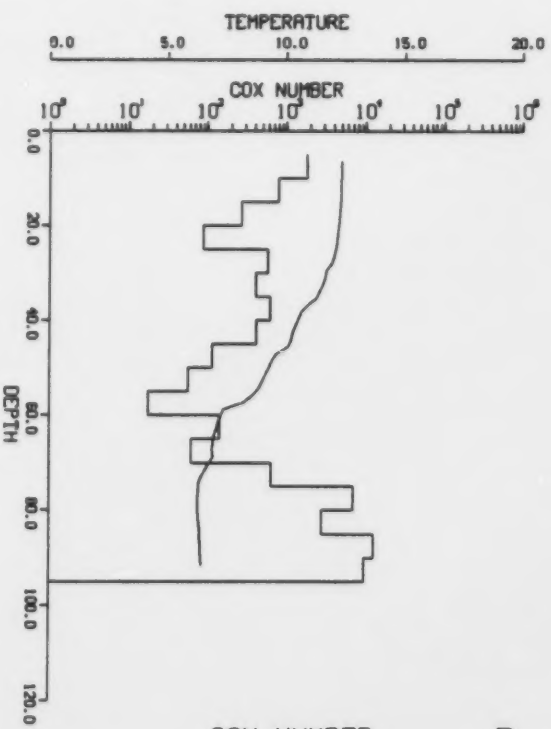

88036 - 235 CHI-THETA




VERT DIFFUSIVITY

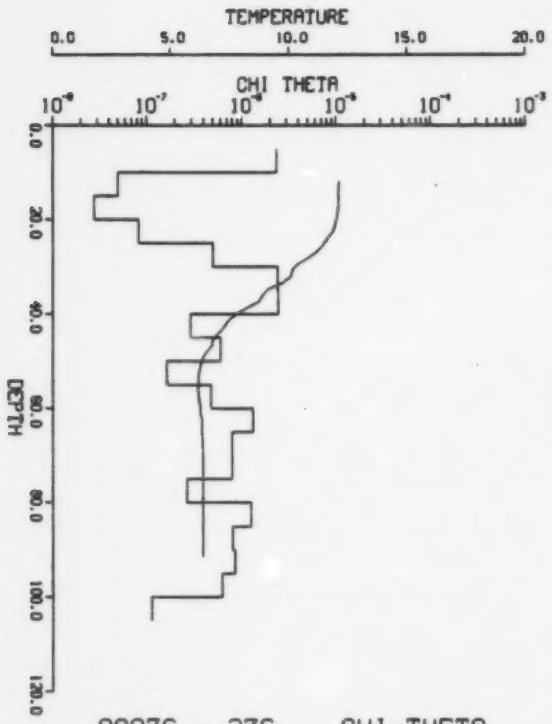



DISSIPATION

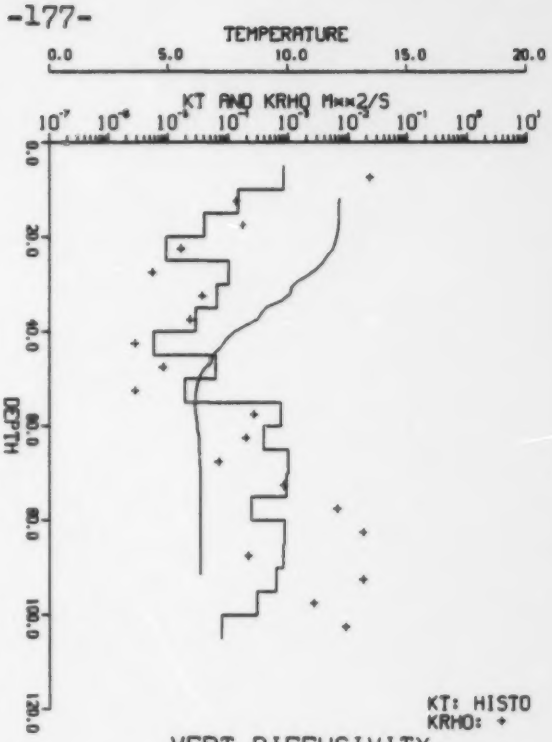



COX NUMBER

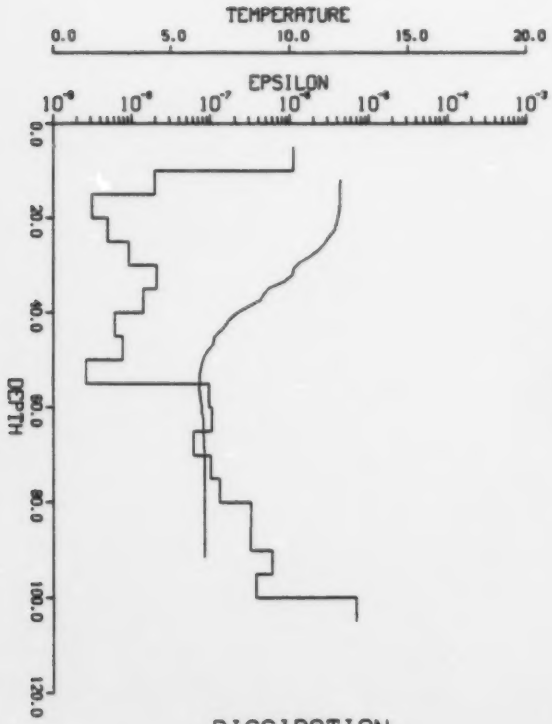
B



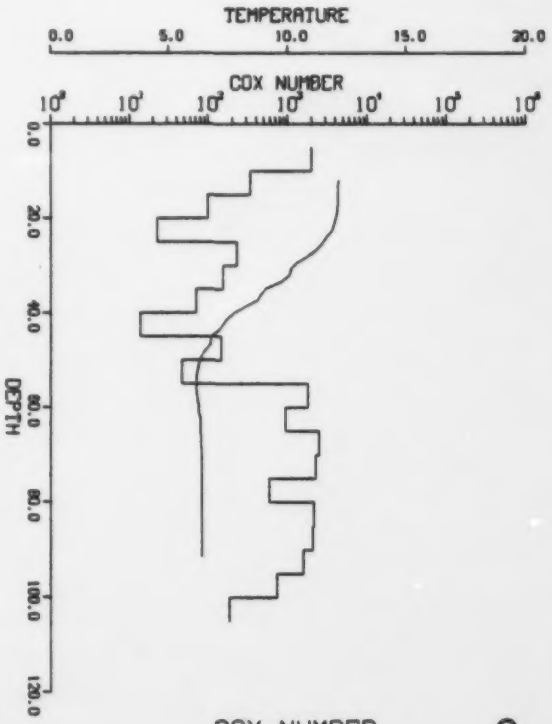

88036 - 236 CHI-THETA



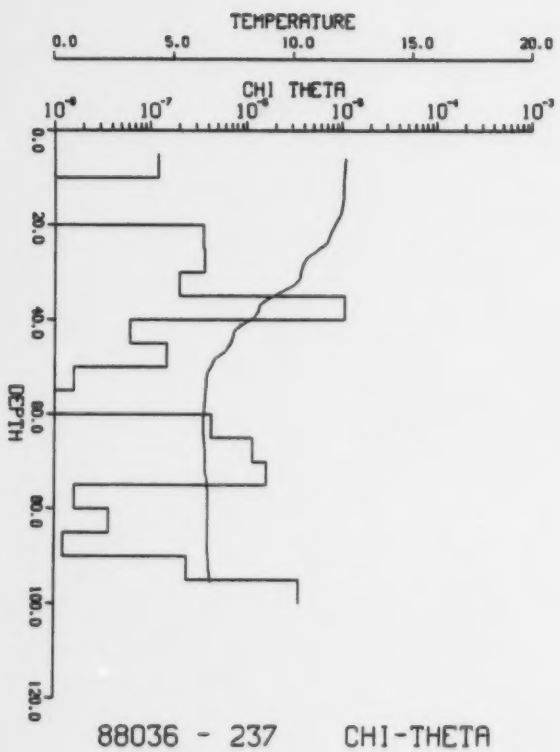

VERT DIFFUSIVITY



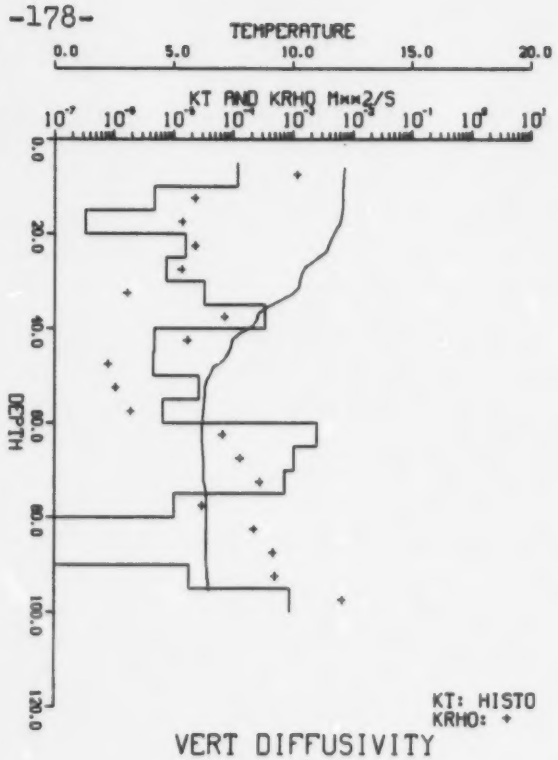

DISSIPATION



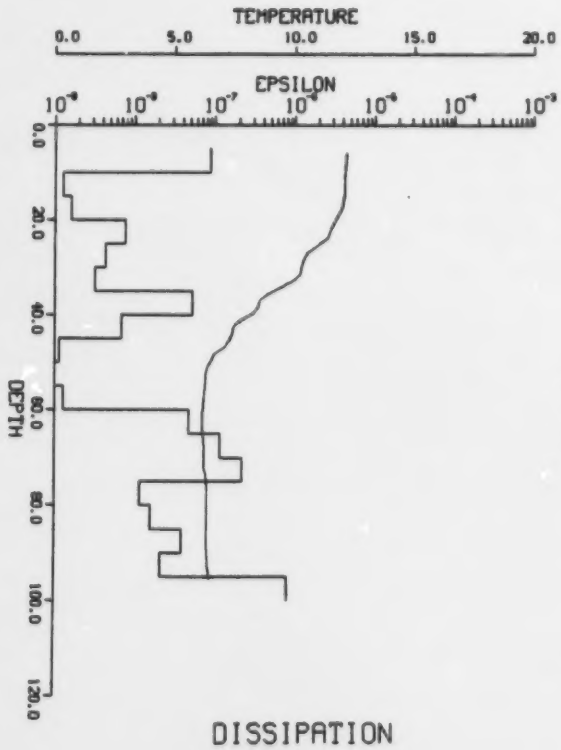

COX NUMBER C




88036 - 237 CHI-THETA




VERT DIFFUSIVITY

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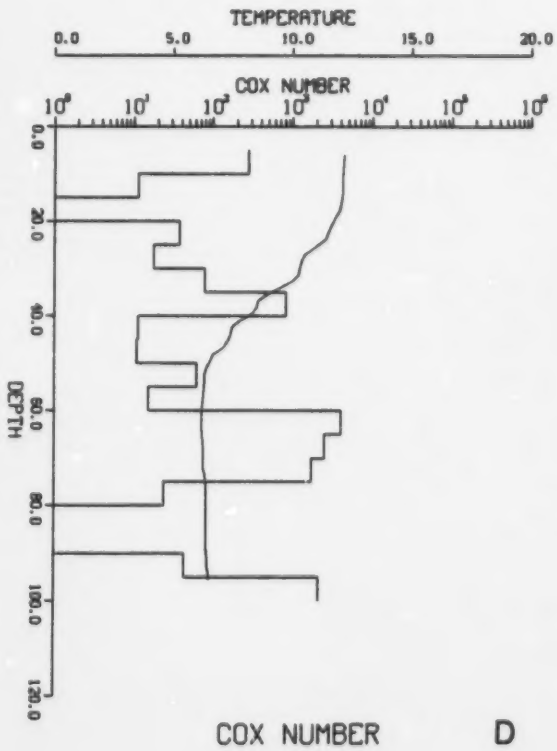


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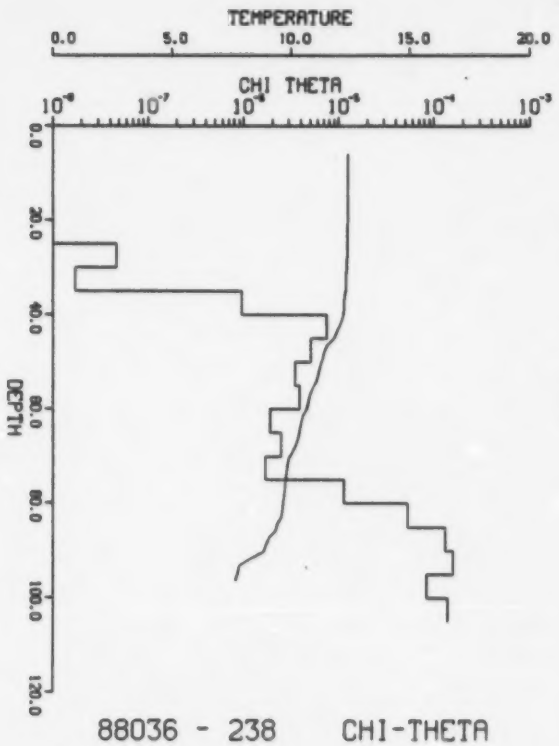
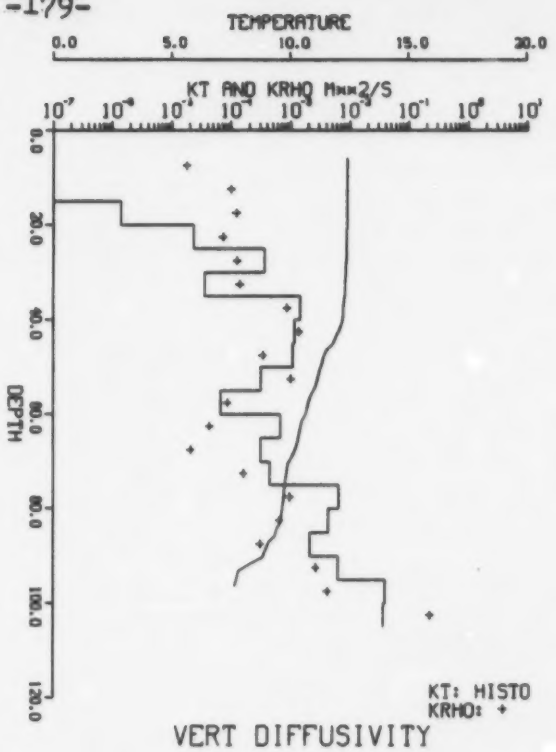



88036 - 238 CHI-THETA

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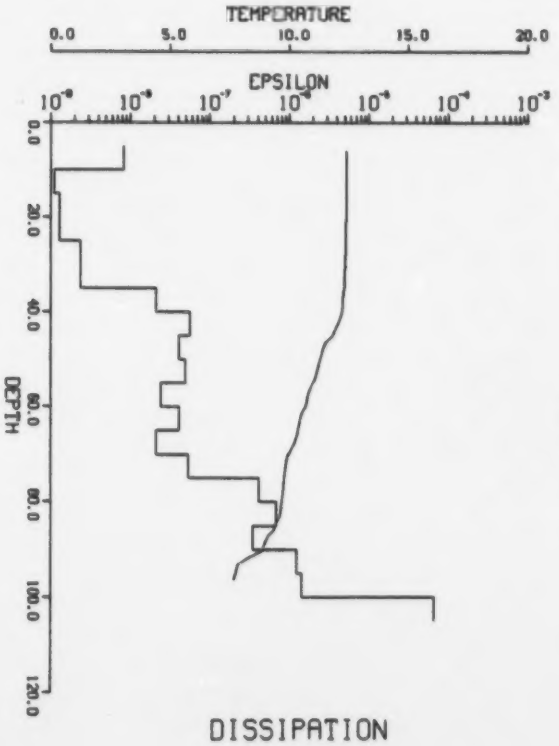


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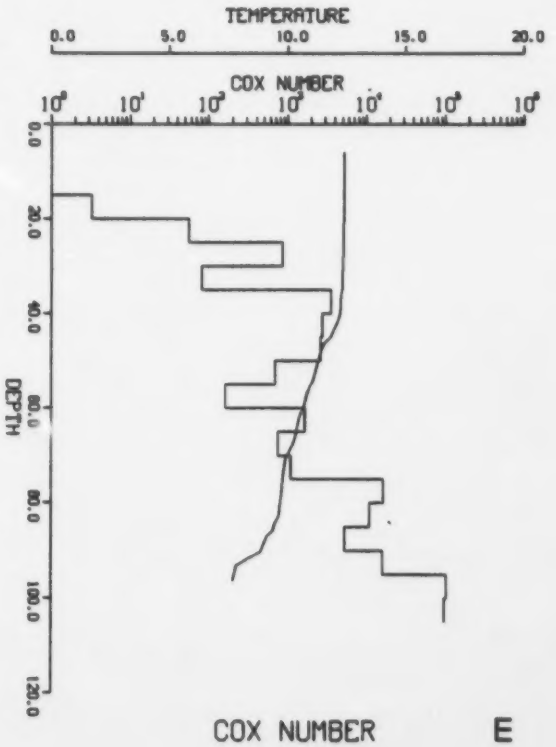


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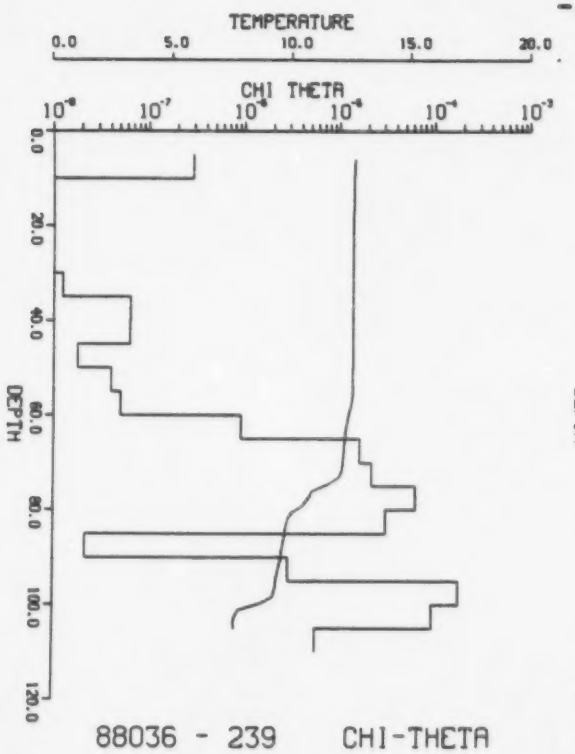
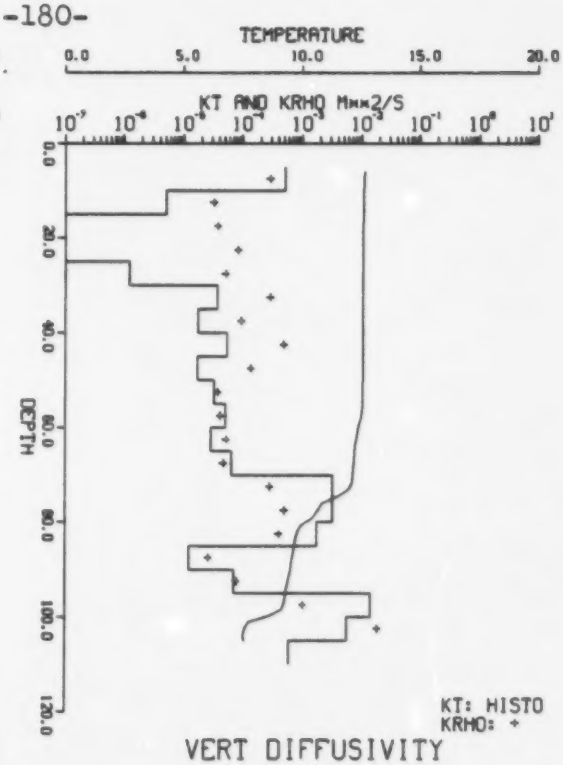



88036 - 239 CHI-THETA

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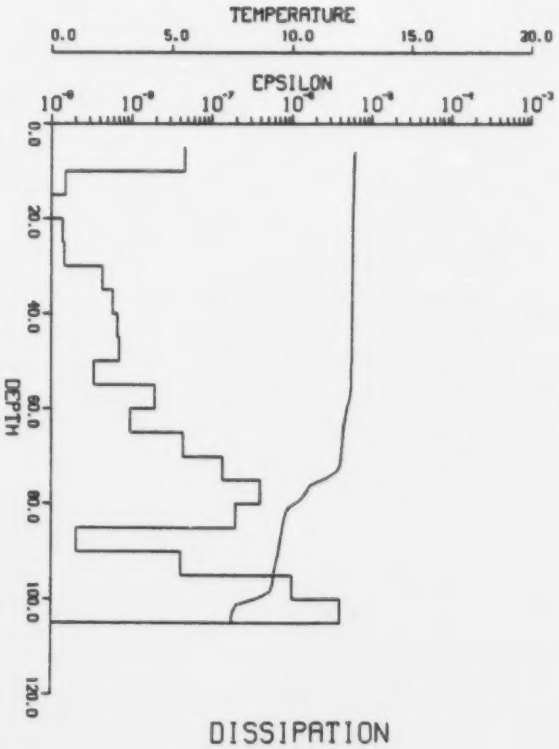


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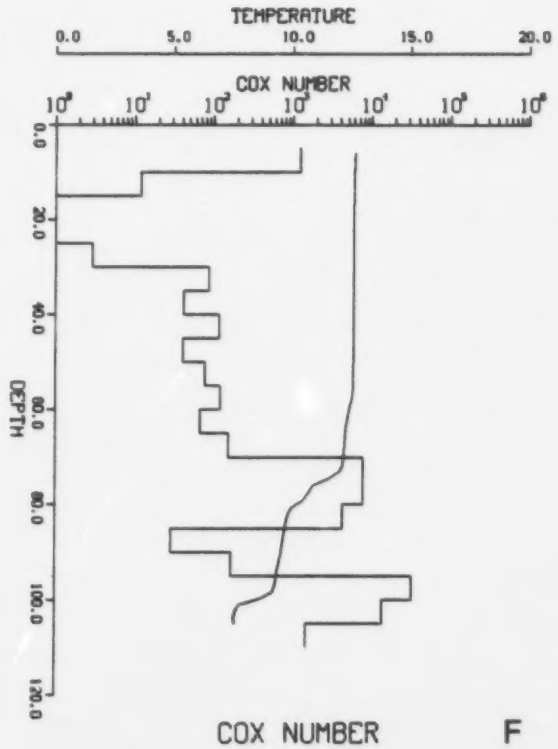
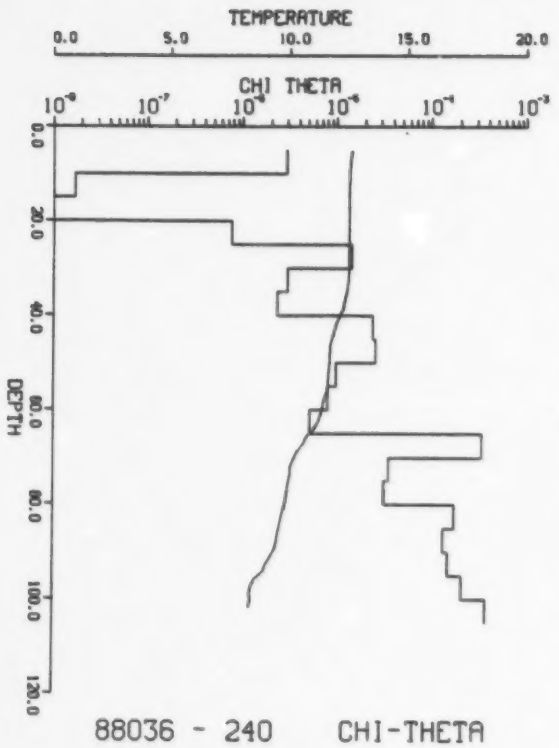
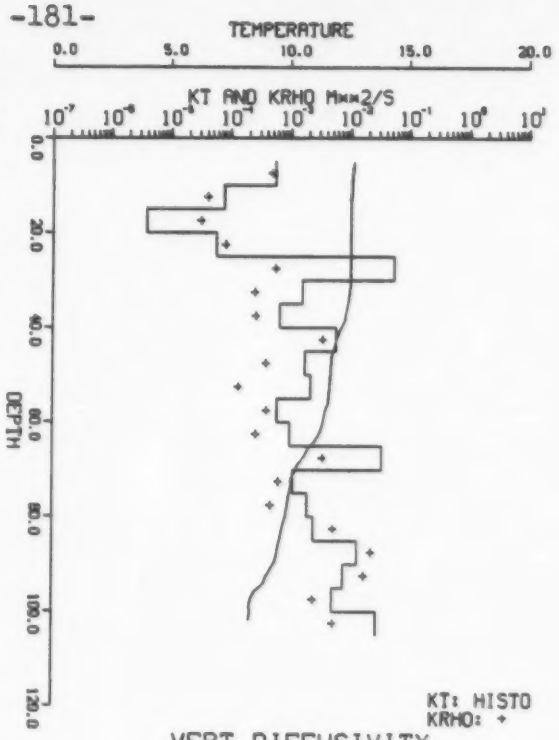



COX NUMBER

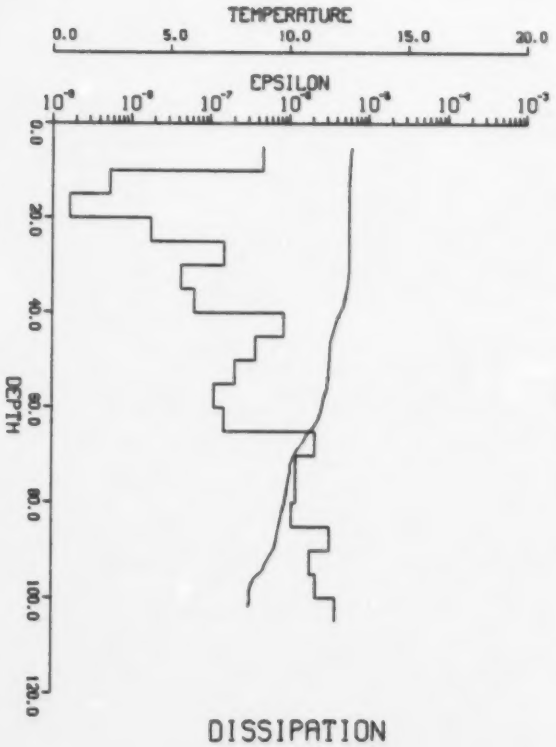
F




88036 - 240 CHI-THETA




VERT DIFFUSIVITY

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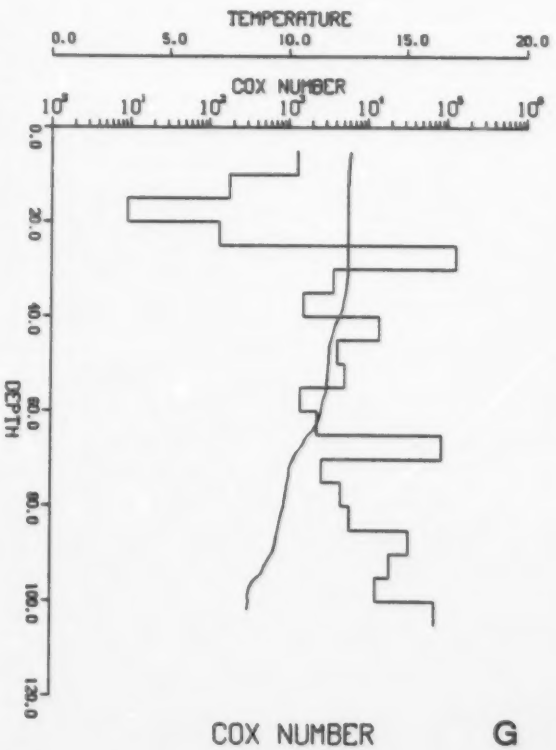



COX NUMBER

G

# SITE 2A36

42°04.79N, 66°46.60W

TABLE 11: COMBINED CURRENT AND DISSIPATION

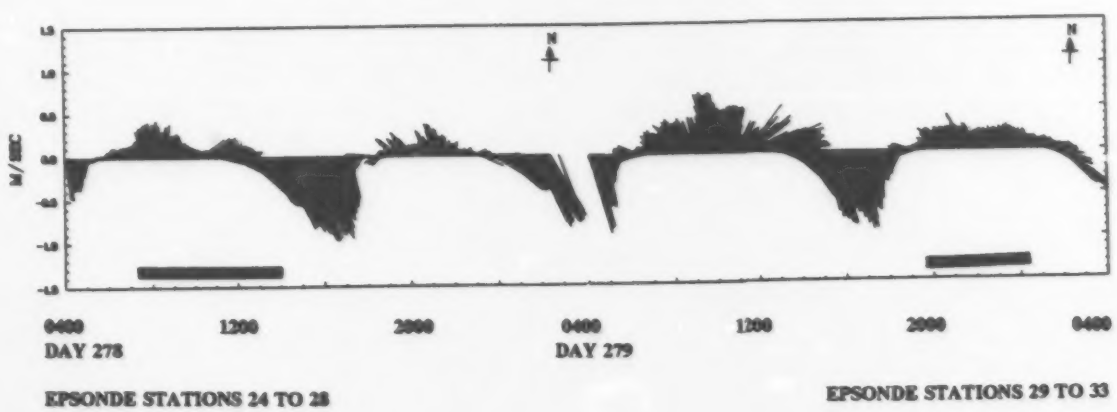
| Station | TimeEPS | Depth | Drops | Current | IntEPS | ErrEPS |
|---|---|---|---|---|---|---|
| E224 | 278.3181 | 65.80 | 8 | 0.493 | 0.0690 | 0.0198 |
| E225 | 278.3646 | 66.30 | 3 | 0.437 | 0.0177 | 0.0038 |
| E227 | 278.5444 | 67.10 | 8 | 0.821 | 0.0937 | 0.0301 |
| E228 | 278.5941 | 67.80 | 4 | 1.019 | 0.1221 | 0.0108 |
| E229 | 279.8306 | 65.95 | 8 | 0.413 | 0.0344 | 0.0094 |
| E230 | 279.8788 | 66.10 | 7 | 0.454 | 0.0362 | 0.0094 |
| E231 | 279.9191 | 65.30 | 8 | 0.369 | 0.0247 | 0.0034 |
| E232 | 279.9583 | 67.80 | 8 | 0.332 | 0.0280 | 0.0053 |
| E233 | 279.9997 | 67.35 | 8 | 0.339 | 0.0132 | 0.0009 |

FIGURE 24:

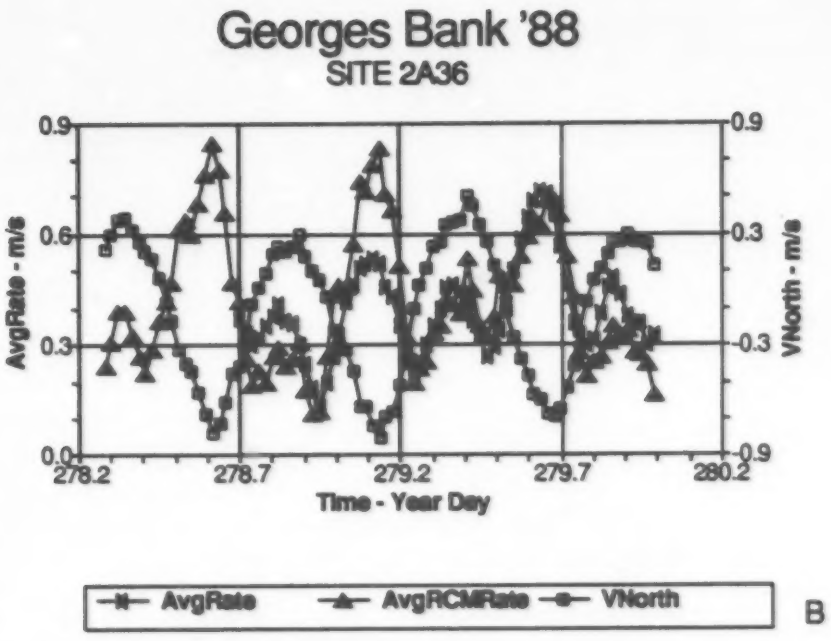
A. Current vector plot for the RCM at 34m depth at site 2 overlapping the EPSONDE anchor station 2A during cruise 88036 (2A36). This anchor station includes EPSONDE stations 224 to 233.

B. The magnitude of the vertically averaged composite RCM and Ametek DCP current and the averaged composite RCM current and northward component at half hour intervals for site 2 coincident with EPSONDE anchor station 2A36. For the time period before day 278.7 no Ametek data were available. Currents have been estimated for this time (for comparison with microstructure quantities below) by comparing the RCM composite data to the RCM and Ametek DCP composite data for periods after day 287.7.

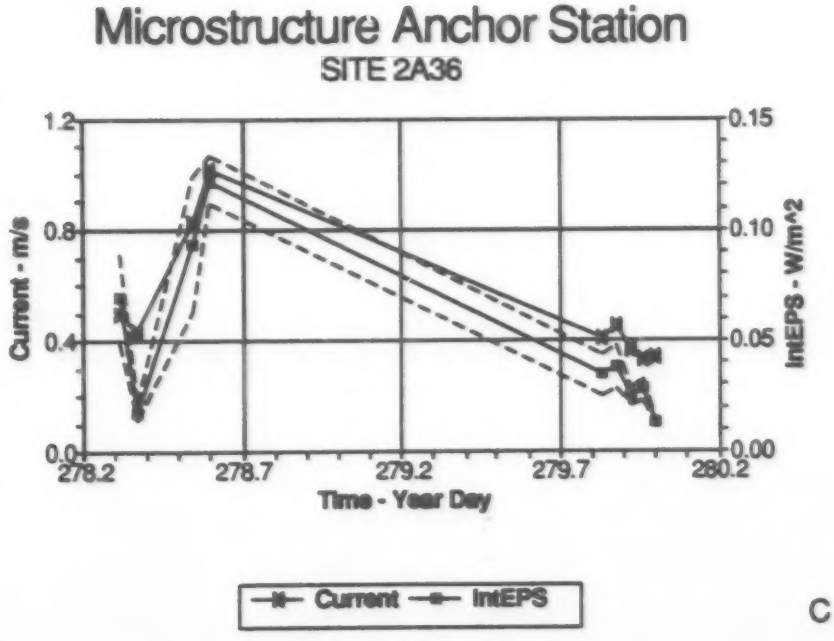
C. The magnitude of the vertically averaged composite current interpolated to the mean EPSONDE station time and the integrated dissipation, IntEPS, for each EPSONDE station during anchor station 2A36. Error limits are indicated for IntEPS.




A


Georges Bank '88
SITE 2A36
AvgRate - m/s
VNorth - m/s
0.9
0.6
0.3
0.0
-0.3
-0.9
278.2
278.7
279.2
279.7
280.2
Time - Year Day
AvgRate
AvgRCMRate
VNorth

B

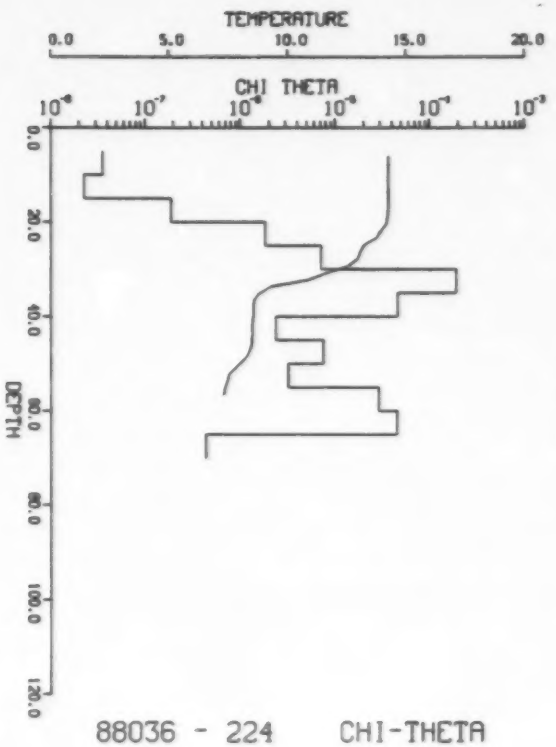

Microstructure Anchor Station
SITE 2A36
Current - m/s
IntEPS - W/m^2
1.2
0.8
0.4
0.0
0.15
0.10
0.05
0.00
278.2
278.7
279.2
279.7
280.2
Time - Year Day
Current
IntEPS

C

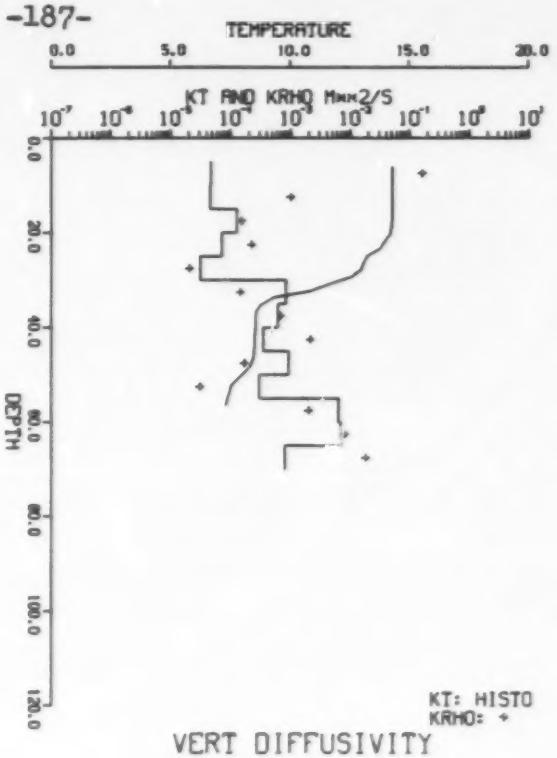
FIGURE 25: Profiles of microstructure quantities for stations 224 to 233 for anchor station 2A36.
- Each page contains a profile of a microstructure quantity averaged over 5 m vertical bins overlaid on a profile of temperature.
- The upper left panel is Chi-Theta, the dissipation of temperature variance.
- The upper right panel contains profiles of vertical diffusivity KT (for temperature) and KRHO for density.
- The lower left panel contains a profile of dissipation, EPSILON.
- The lower right panel shows the profile for Cox number.

The stations are shown in the following order:

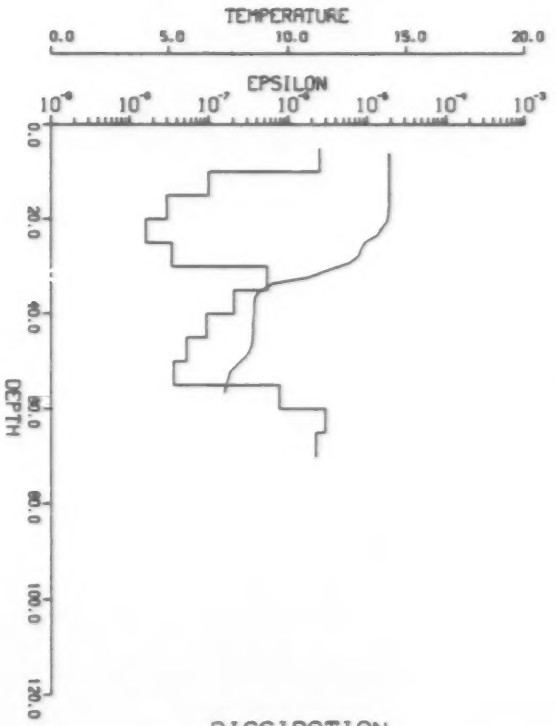
A. Station 224
B. Station 225
C. Station 227
D. Station 228
E. Station 229
F. Station 230
G. Station 231
H. Station 232
I. Station 233



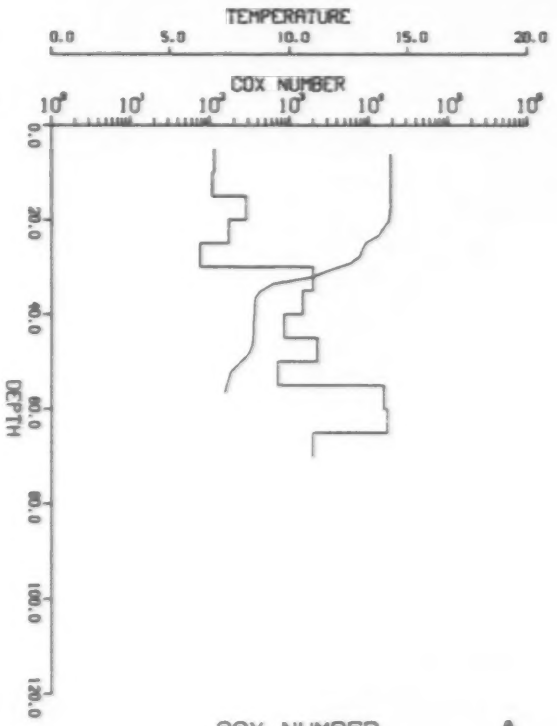

88036 - 224 CHI-THETA



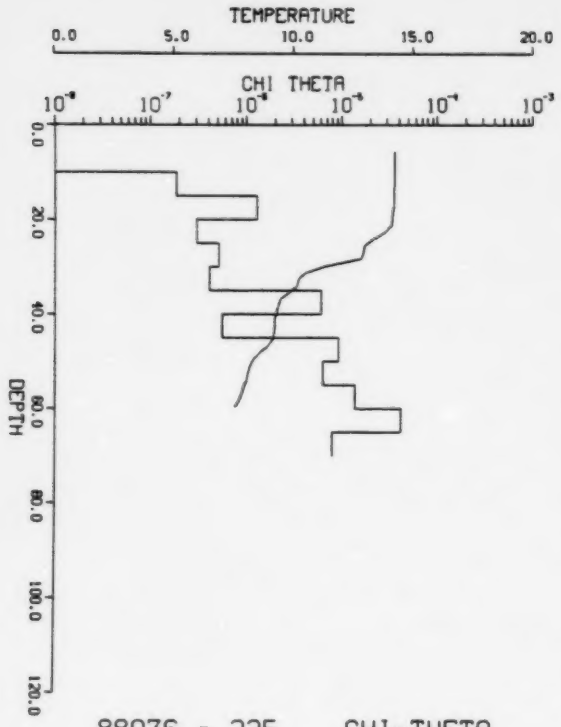

VERT DIFFUSIVITY



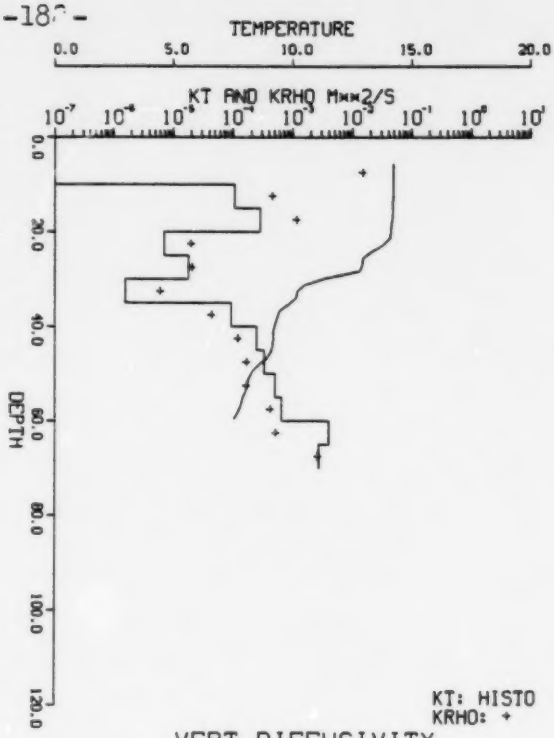

DISSIPATION



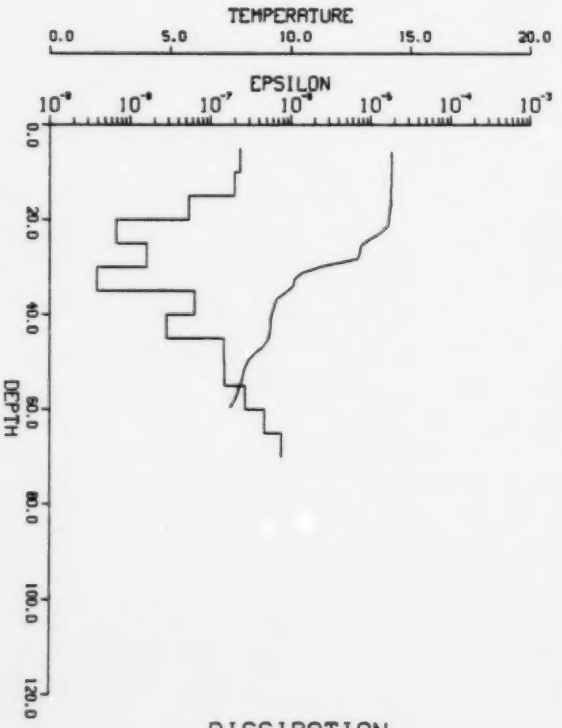

COX NUMBER A




88036 - 225 CHI-THETA




VERT DIFFUSIVITY

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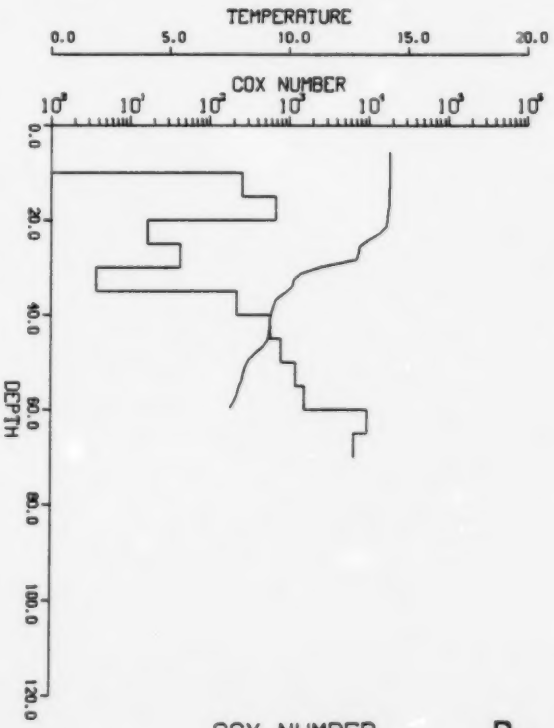
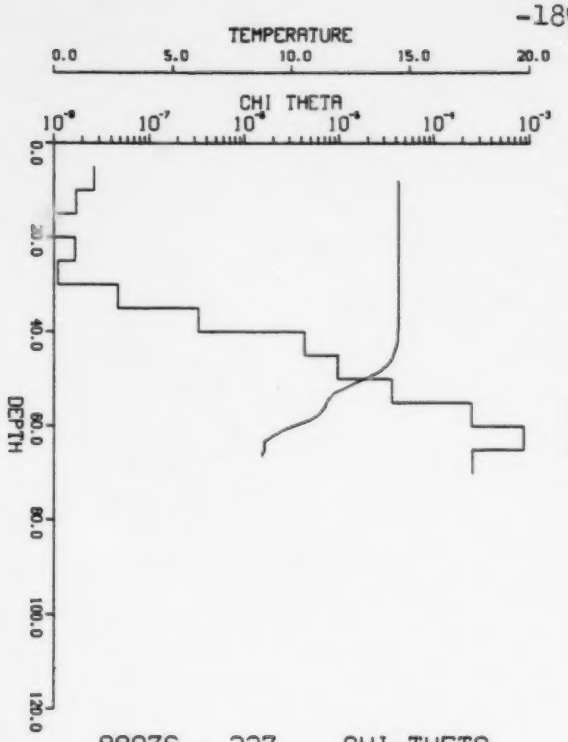
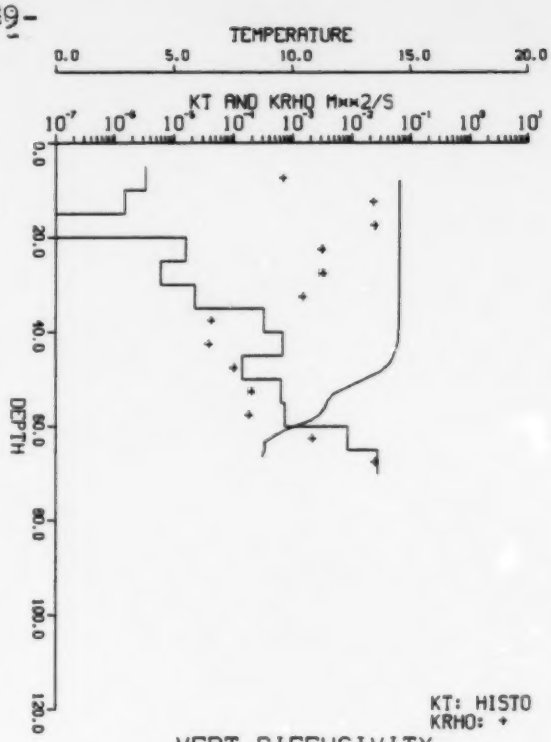


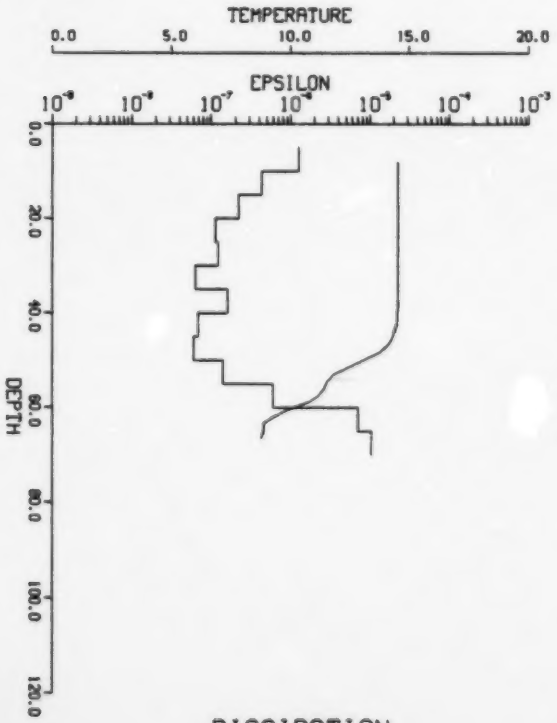

COX NUMBER B



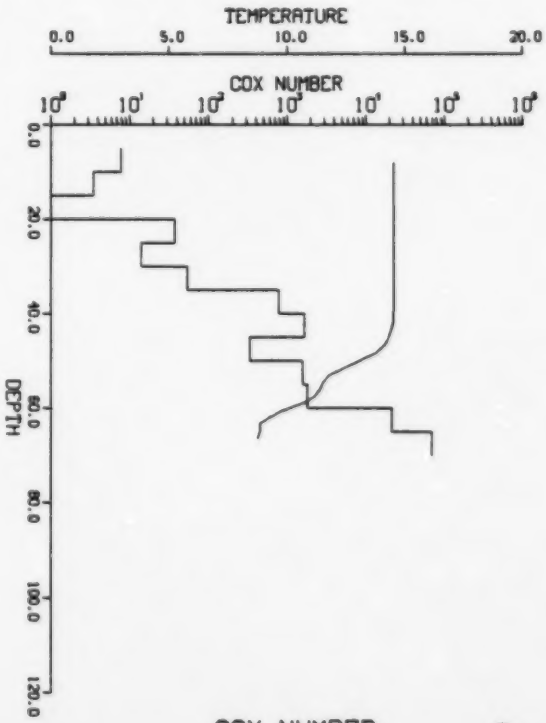

88036 - 227 CHI-THETA




VERT DIFFUSIVITY

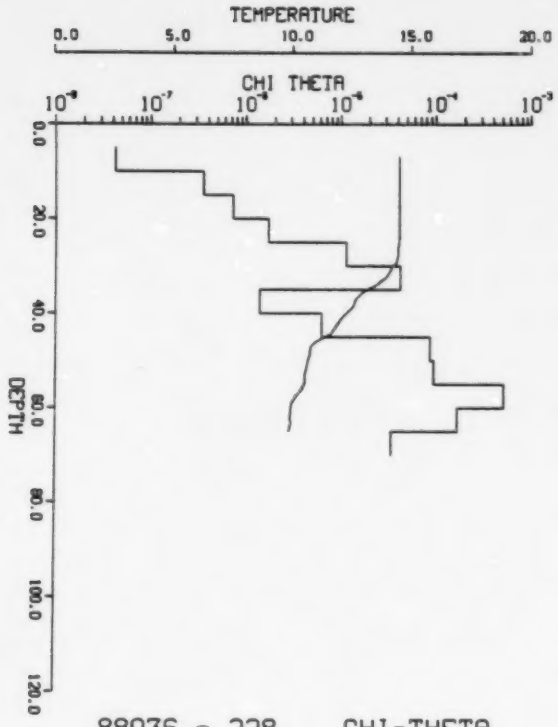



DISSIPATION

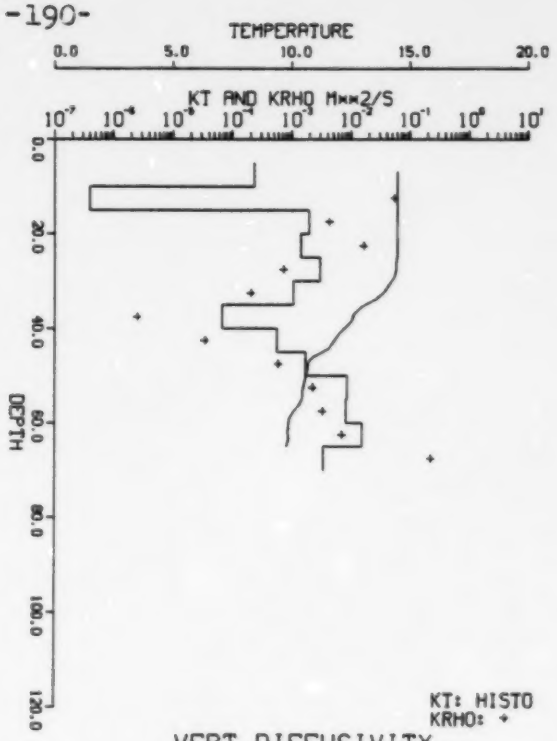



COX NUMBER

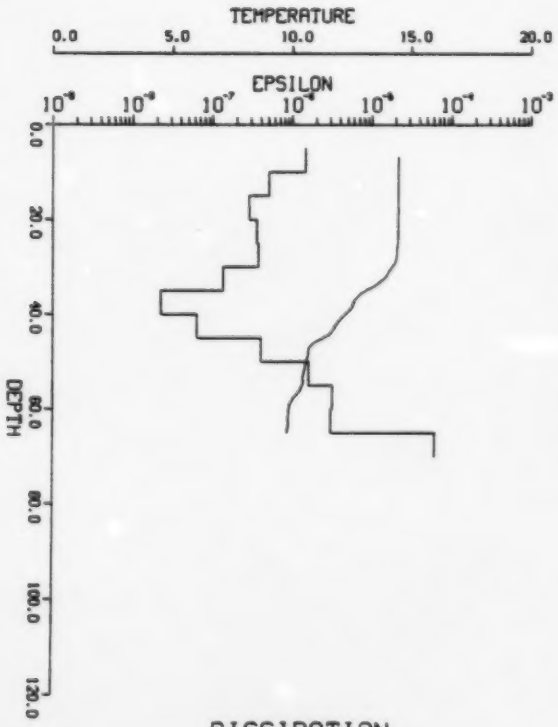
C




88036 - 228 CHI-THETA




VERT DIFFUSIVITY

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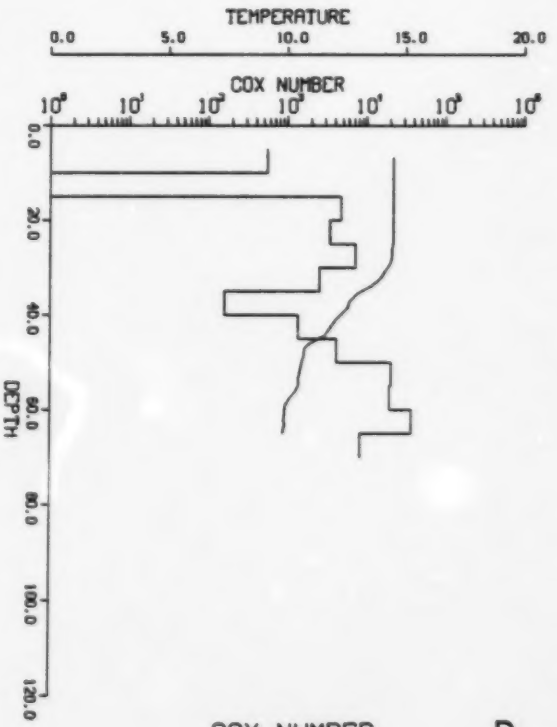
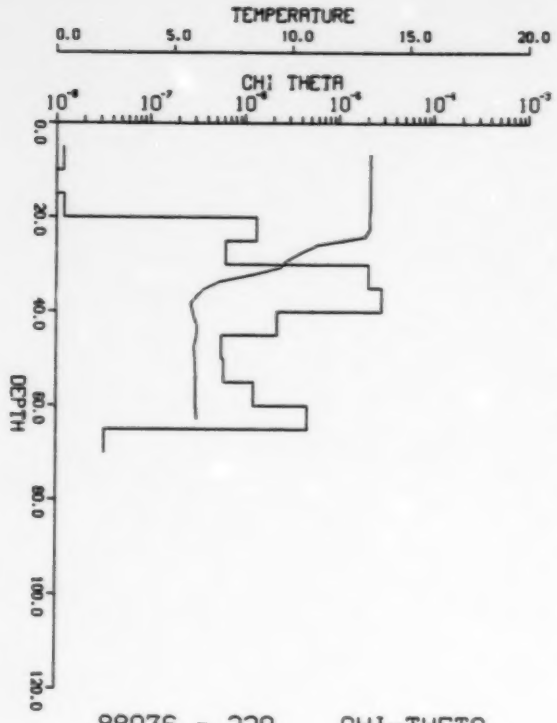
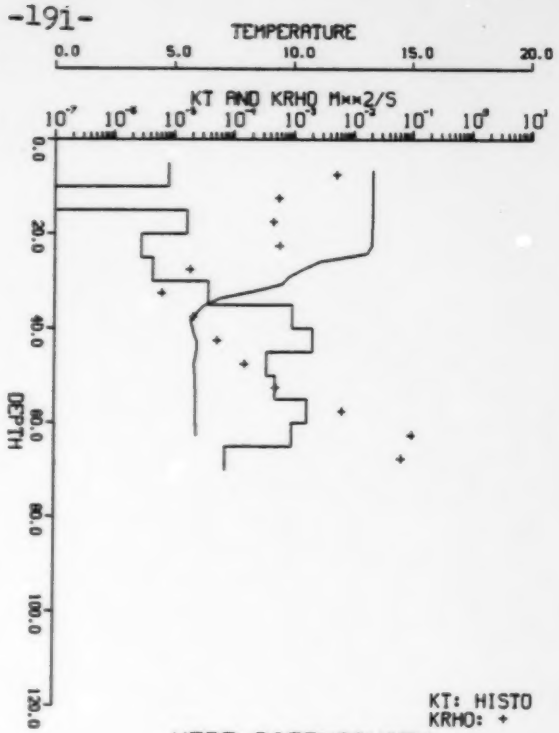



COX NUMBER D




88036 - 229 CHI-THETA

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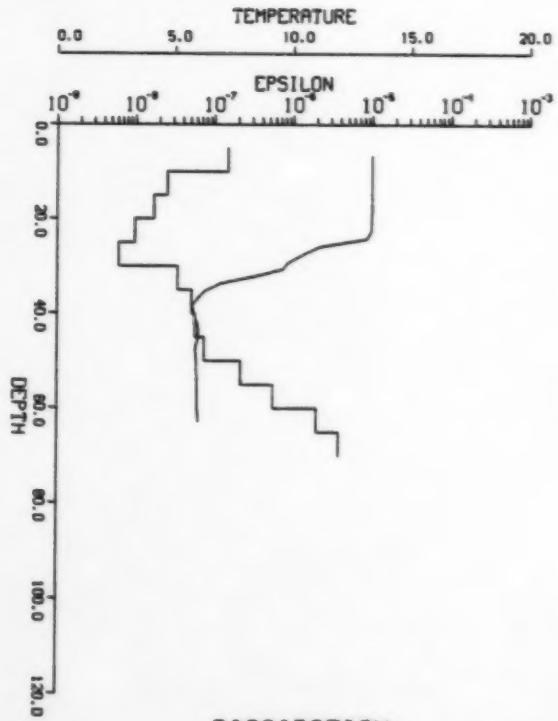


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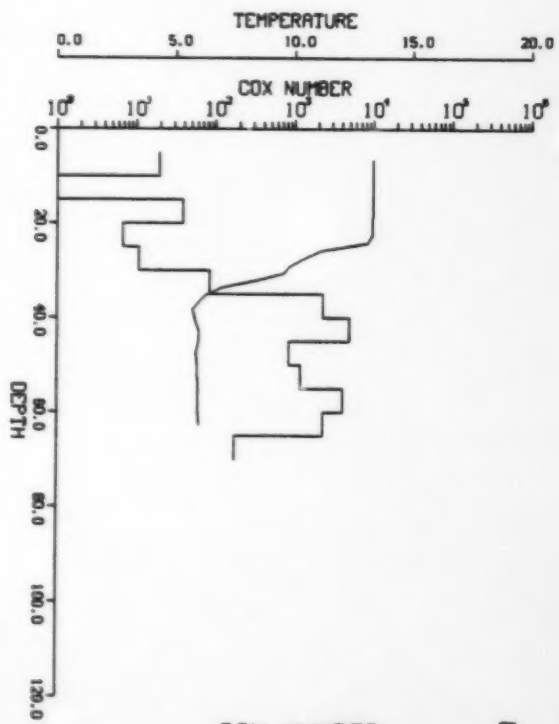


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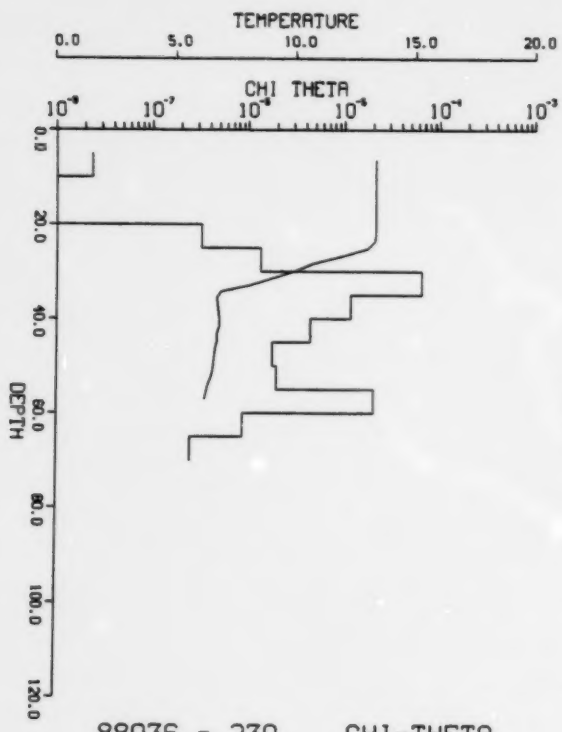
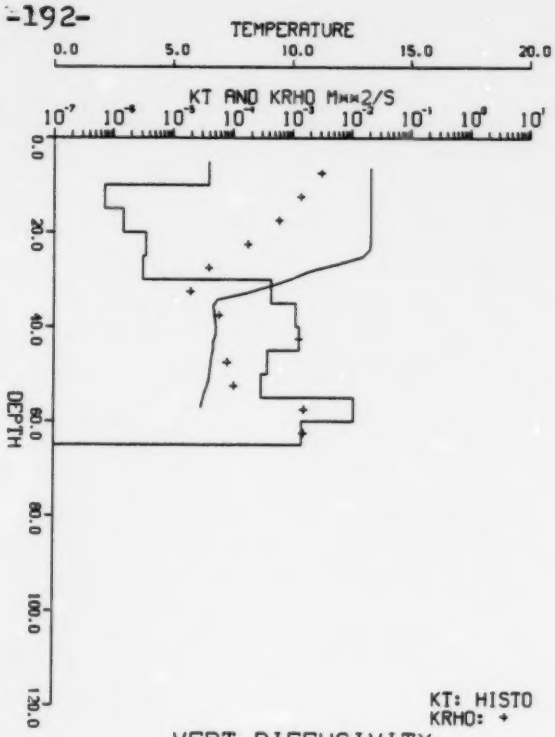



88036 - 230 CHI-THETA

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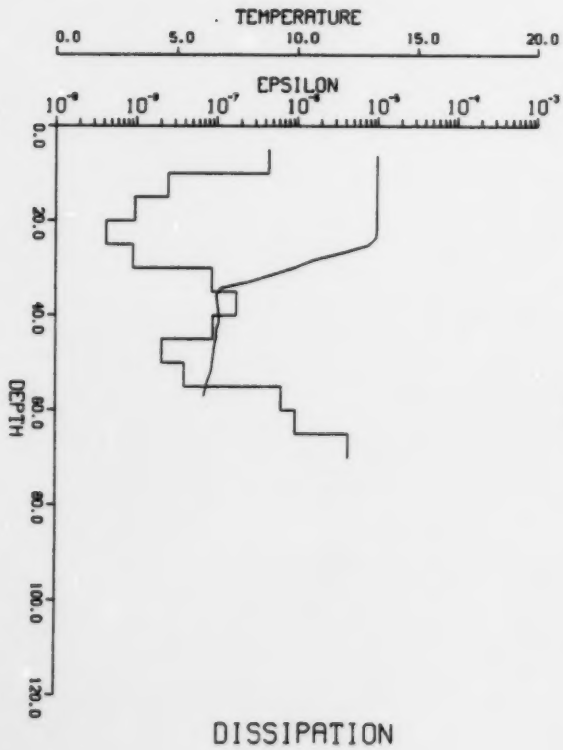


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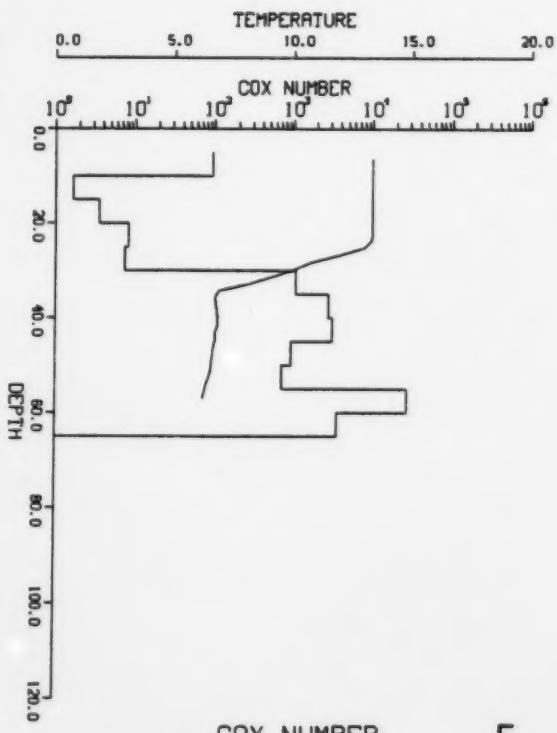
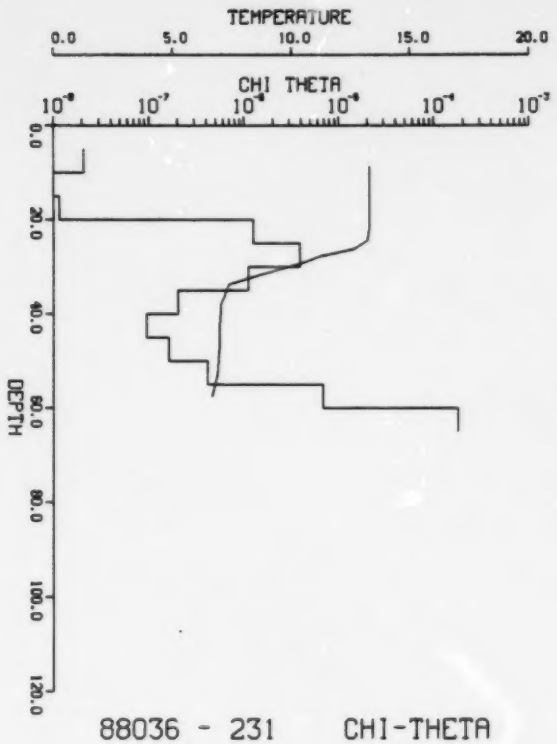
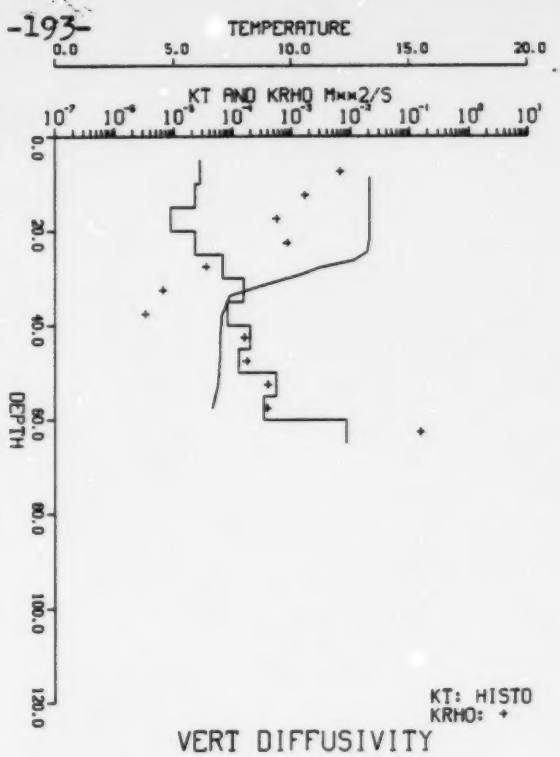



COX NUMBER

F




88036 - 231 CHI-THETA

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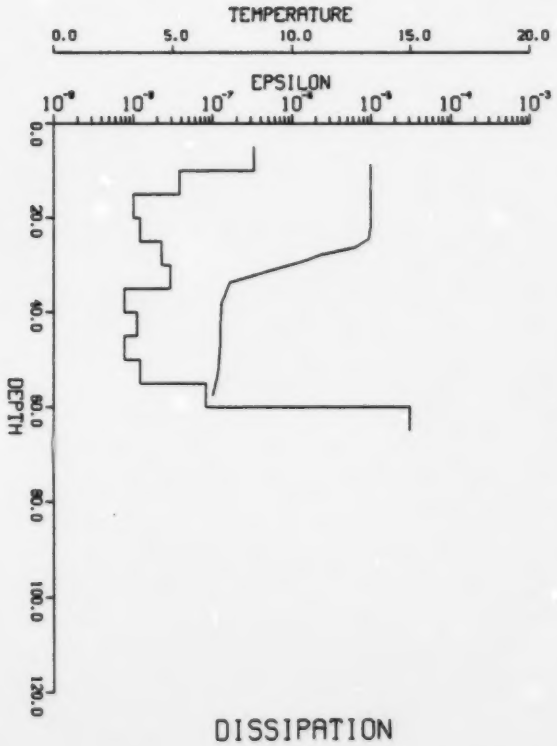
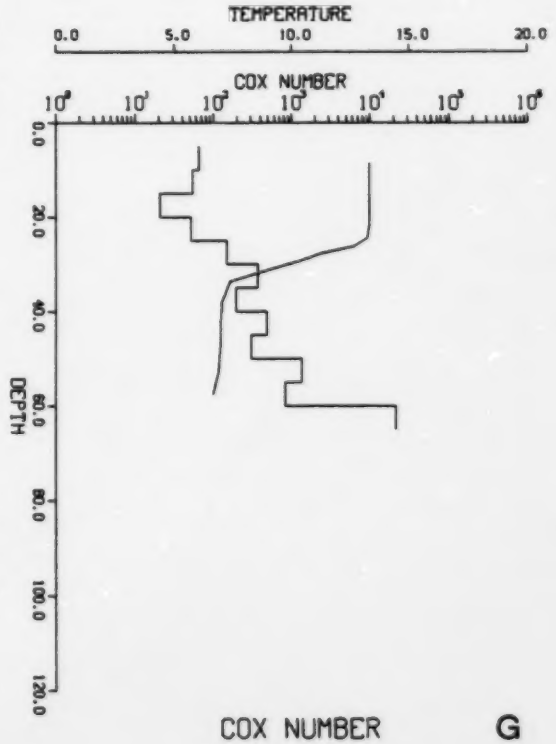
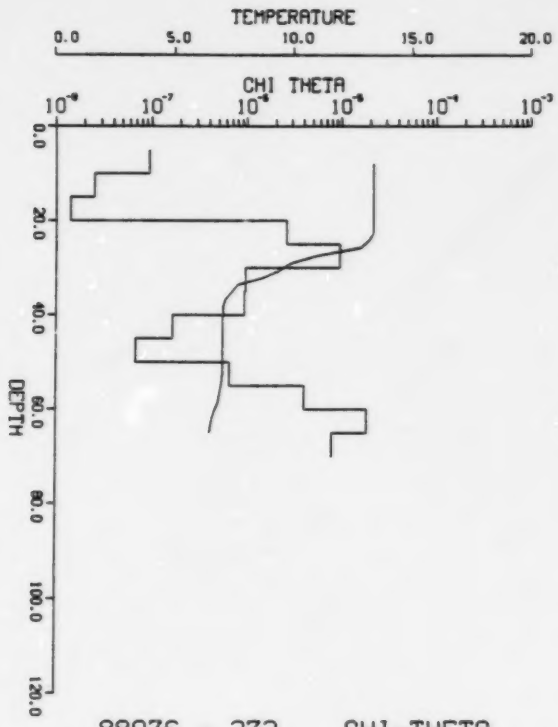


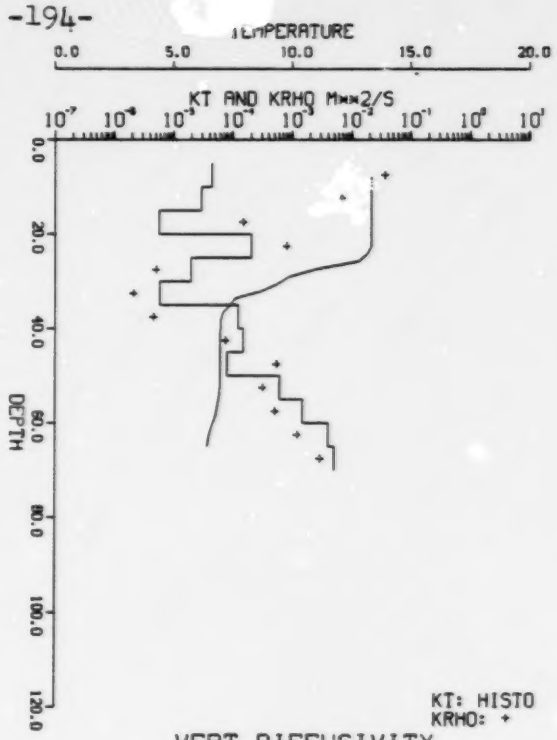

DISSIPATION



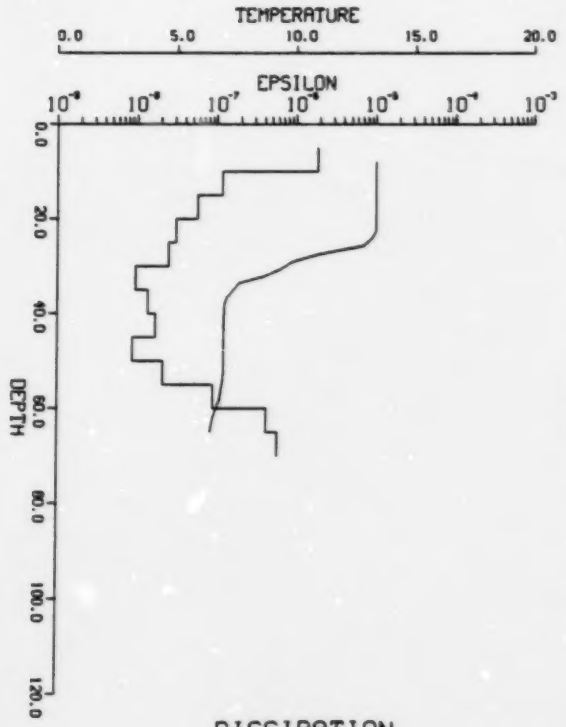

COX NUMBER G



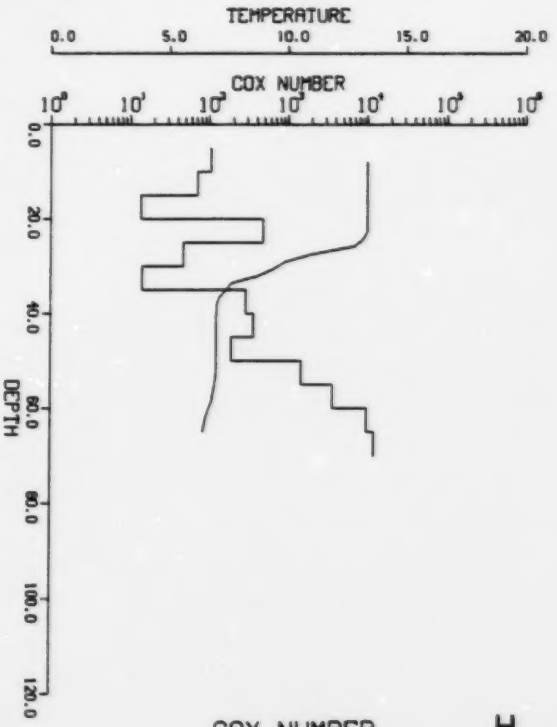

88036 - 232 CHI-THETA



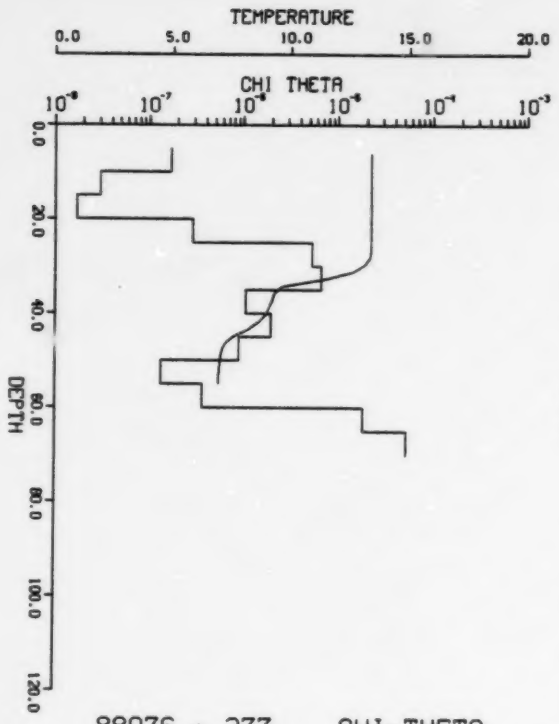

VERT DIFFUSIVITY



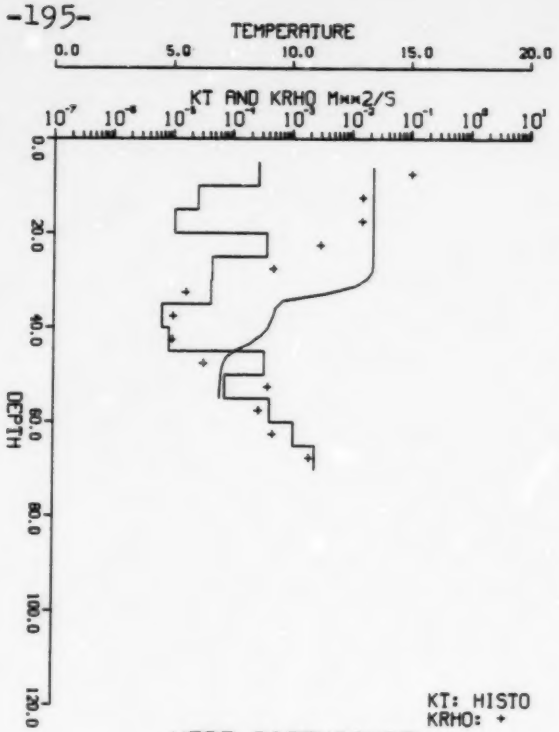

DISSIPATION



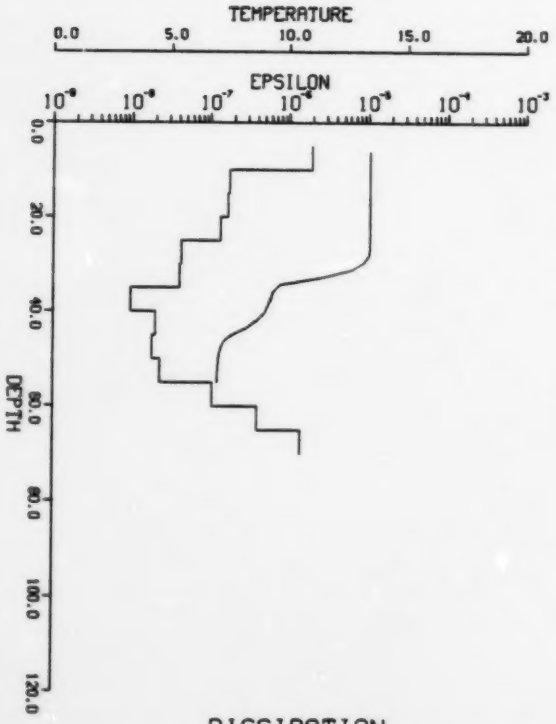

COX NUMBER H



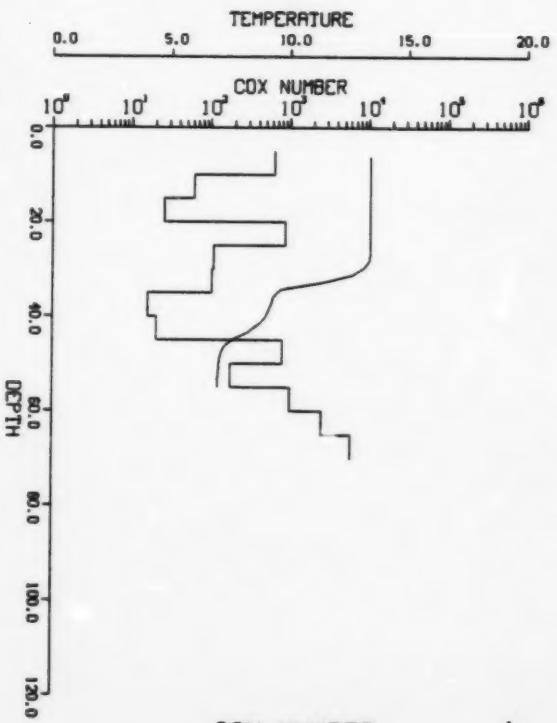

88036 - 233 CHI-THETA




VERT DIFFUSIVITY




DISSIPATION




COX NUMBER

# SITE 3A36

41°59.45N, 66°46.08W

TABLE 12: COMBINED CURRENT AND DISSIPATION

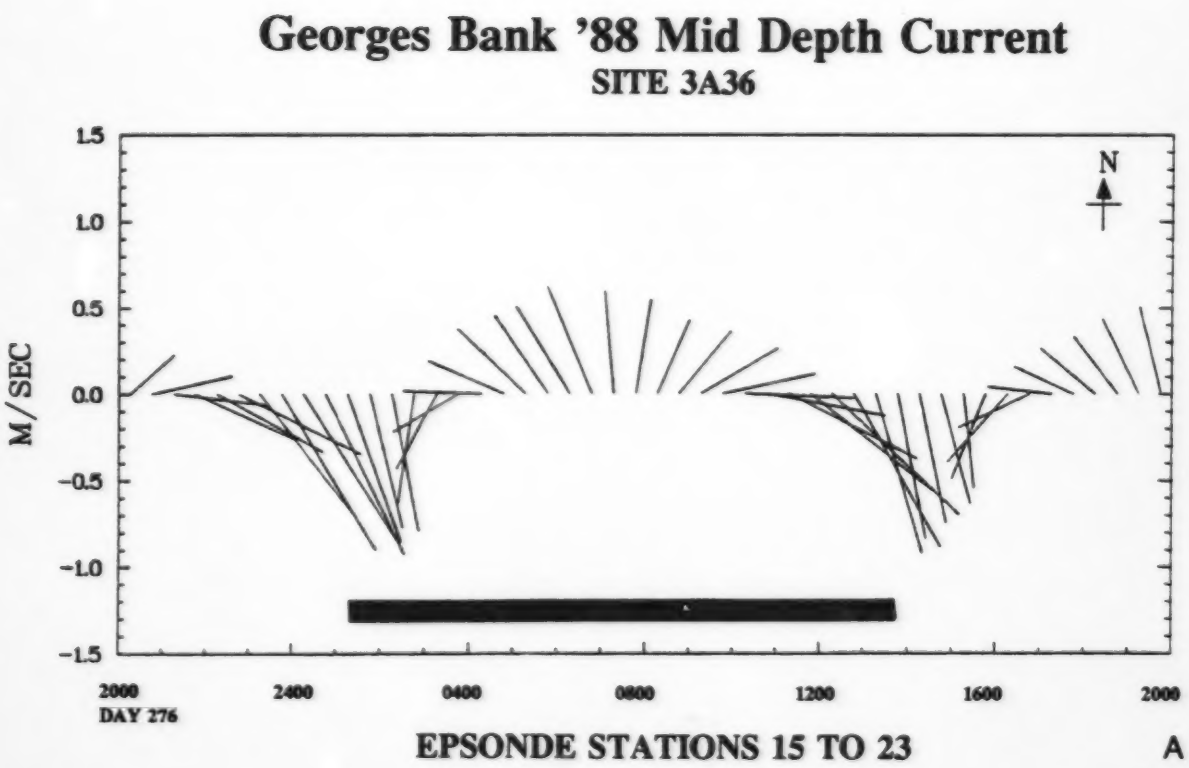
| Station | TimeEPS | Depth | Drops | Current | IntEPS | ErrEPS |
|---|---|---|---|---|---|---|
| E215 | 277.0649 | 62.75 | 8 | 0.700 | 0.0832 | 0.0104 |
| E216 | 277.1097 | 63.25 | 8 | 0.466 | 0.0335 | 0.0114 |
| E217 | 277.2667 | 65.90 | 7 | 0.522 | 0.0197 | 0.0020 |
| E219 | 277.3726 | 65.50 | 8 | 0.480 | 0.0052 | 0.0009 |
| E220 | 277.4181 | 64.65 | 8 | 0.545 | 0.0067 | 0.0013 |
| E221 | 277.4608 | 63.75 | 7 | 0.661 | 0.0491 | 0.0103 |
| E222 | 277.5049 | 62.20 | 8 | 0.766 | 0.0208 | 0.0029 |
| E223 | 277.5573 | 64.45 | 10 | 0.786 | 0.0471 | 0.0051 |

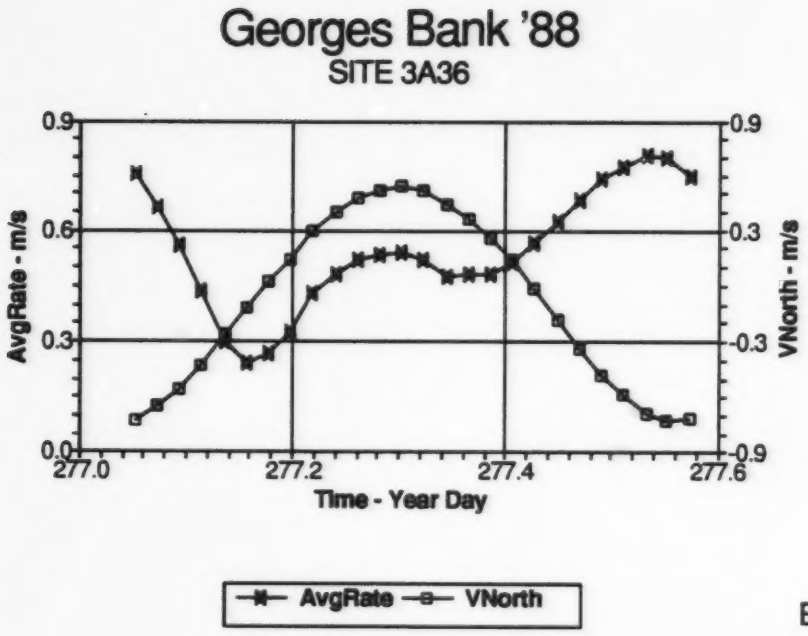
FIGURE 26:

A. Current vector plot for the RCM at 34m depth at site 3 overlapping the EPSONDE anchor station 3A during cruise 88036 (3A36). This anchor station includes EPSONDE stations 215 to 223.

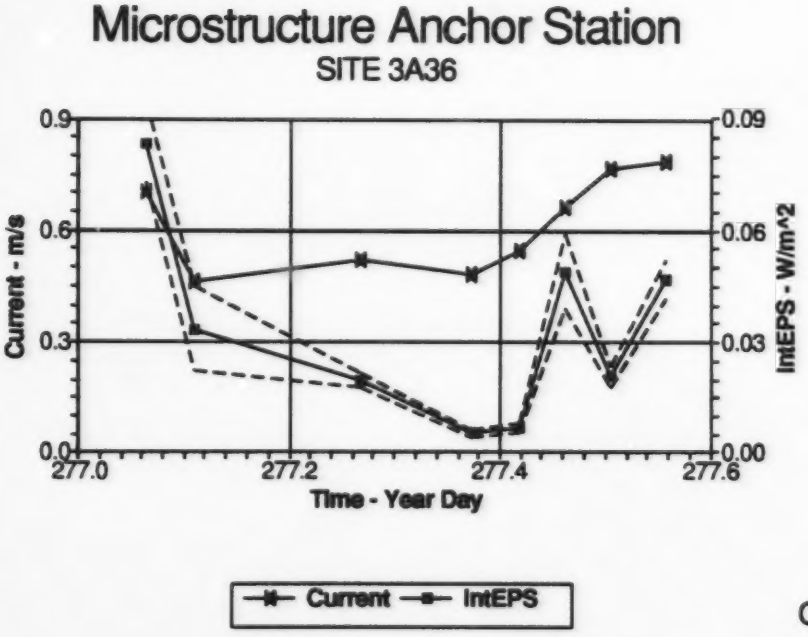
B. The magnitude and the northward component of the vertically averaged composite RCM and Ametek DCP current at half hourly intervals for site 3 coincident with EPSONDE anchor station 3A36.

C. The magnitude of the vertically averaged composite current interpolated to the mean EPSONDE station time and the integrated dissipation, IntEPS, for each EPSONDE station during anchor station 3A36. Error limits are indicated for IntEPS.




Georges Bank '88
SITE 3A36
AvgRate - m/s
VNorth - m/s
0.9
0.6
0.3
0.0
-0.3
-0.9
277.0
277.2
277.4
277.6
Time - Year Day
AvgRate
VNorth

B

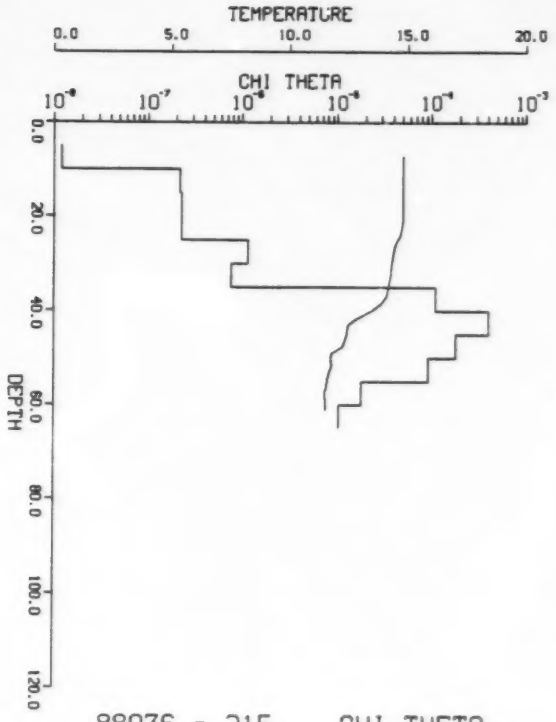

Microstructure Anchor Station
SITE 3A36
Current - m/s
IntEPS - W/m^2
0.9
0.6
0.3
0.0
0.09
0.06
0.03
0.00
277.0
277.2
277.4
277.6
Time - Year Day
Current
IntEPS

C

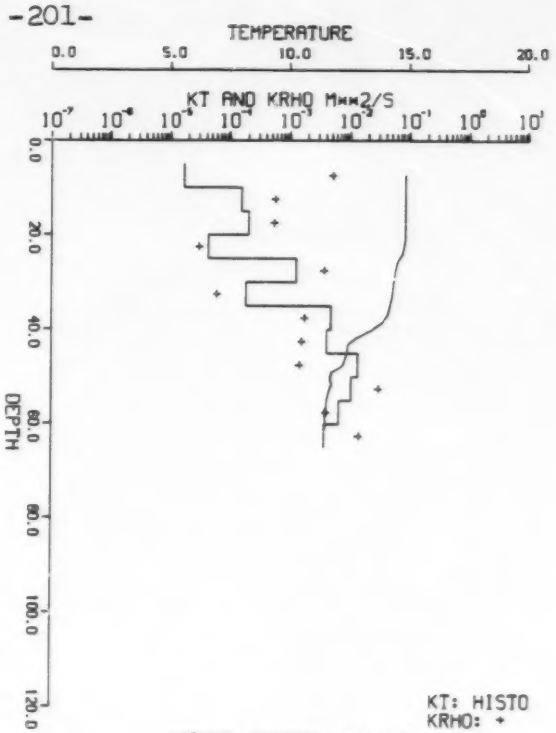
FIGURE 27: Profiles of microstructure quantities for stations 215 to 223 for anchor station 3A36.
- Each page contains a profile of a microstructure quantity averaged over 5 m vertical bins overlaid on a profile of temperature.
- The upper left panel is Chi-Theta, the dissipation of temperature variance.
- The upper right panel contains profiles of vertical diffusivity KT (for temperature) and KRHO for density.
- The lower left panel contains a profile of dissipation, EPSILON.
- The lower right panel shows the profile for Cox number.

The stations are shown in the following order:

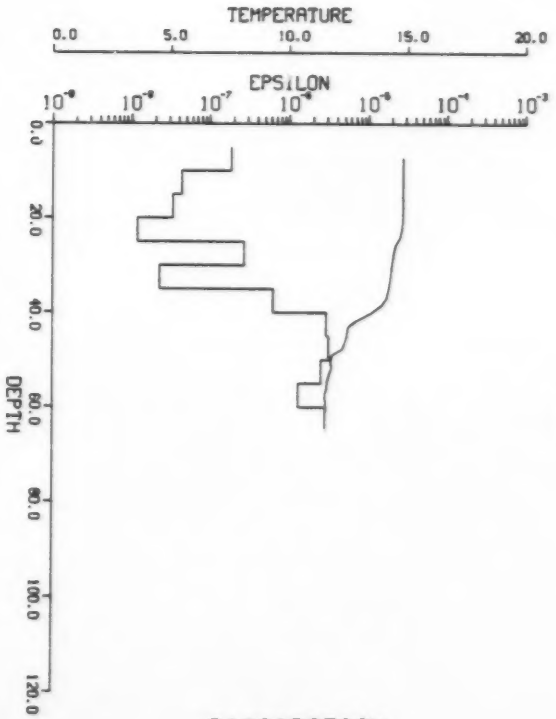
A. Station 215
B. Station 216
C. Station 217
D. Station 219
E. Station 220
F. Station 221
G. Station 222
H. Station 223



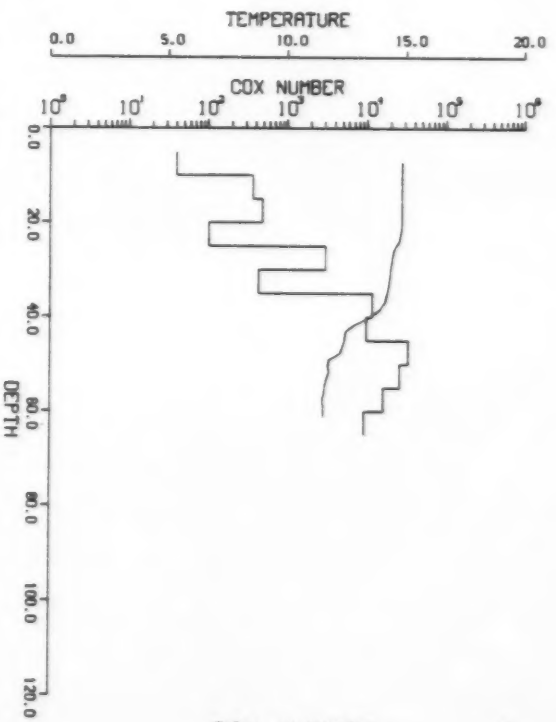

88036 - 215 CHI-THETA



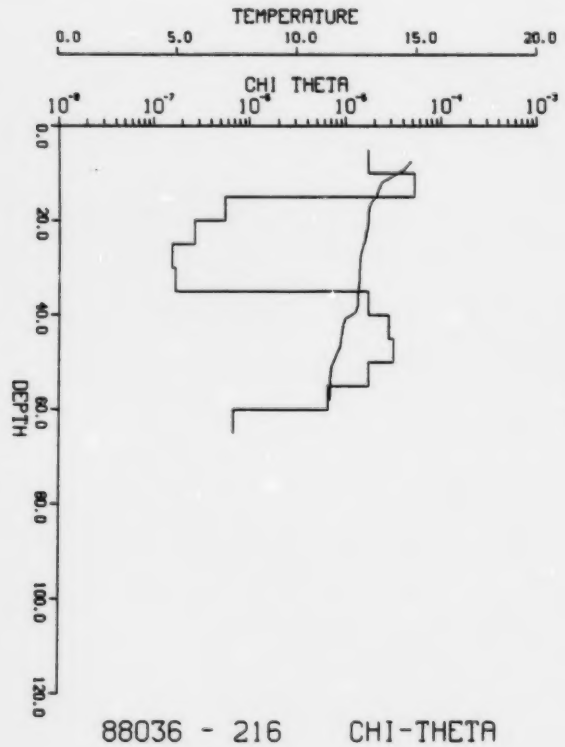

VERT DIFFUSIVITY



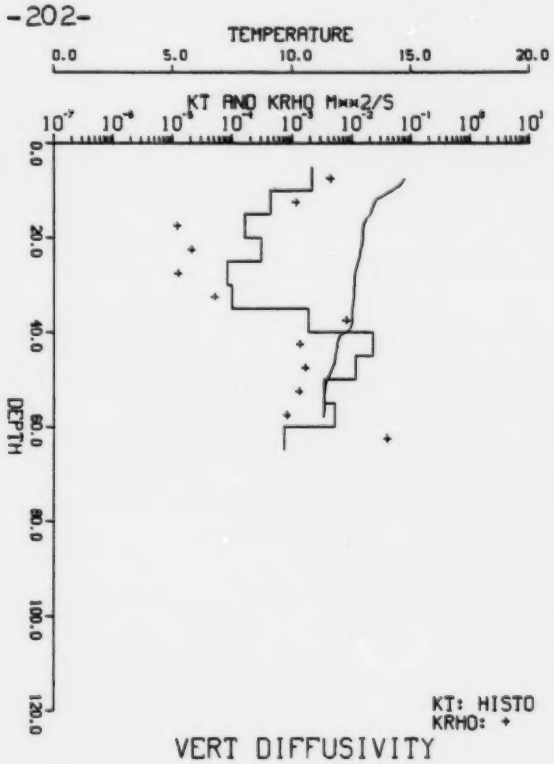

DISSIPATION



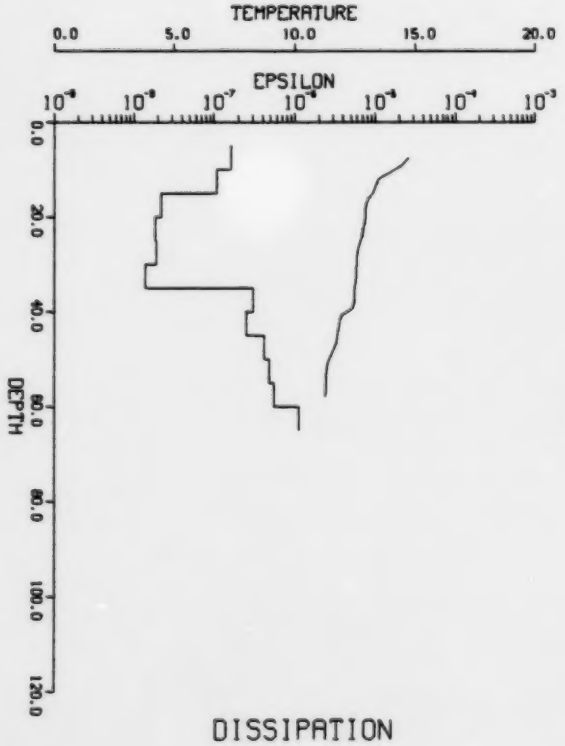

COX NUMBER A




88036 - 216 CHI-THETA




VERT DIFFUSIVITY

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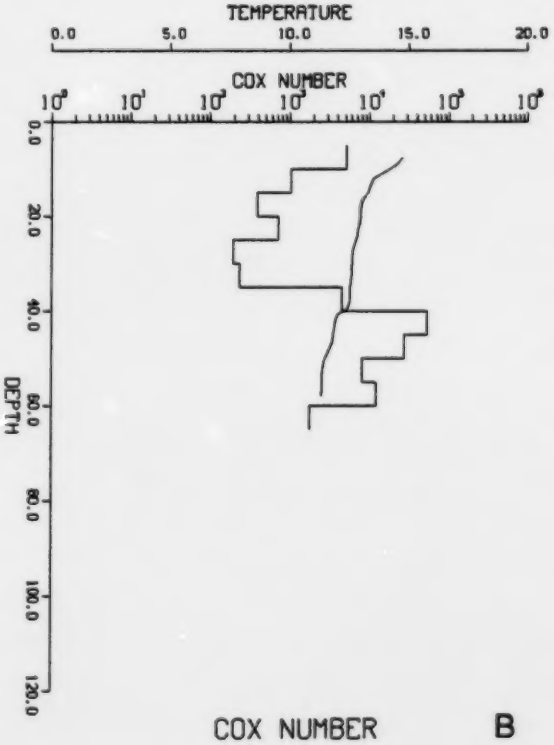
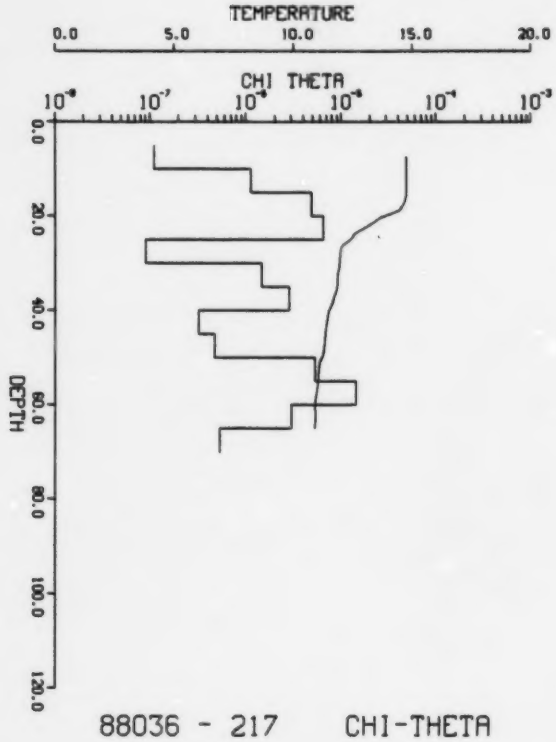
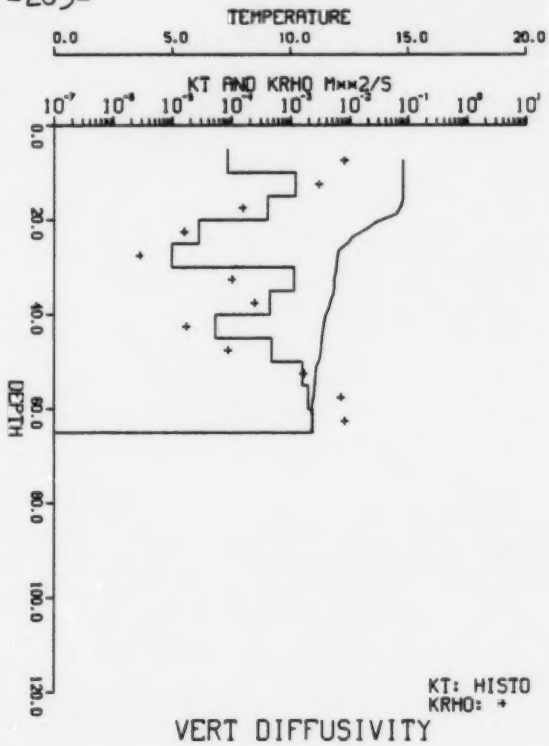


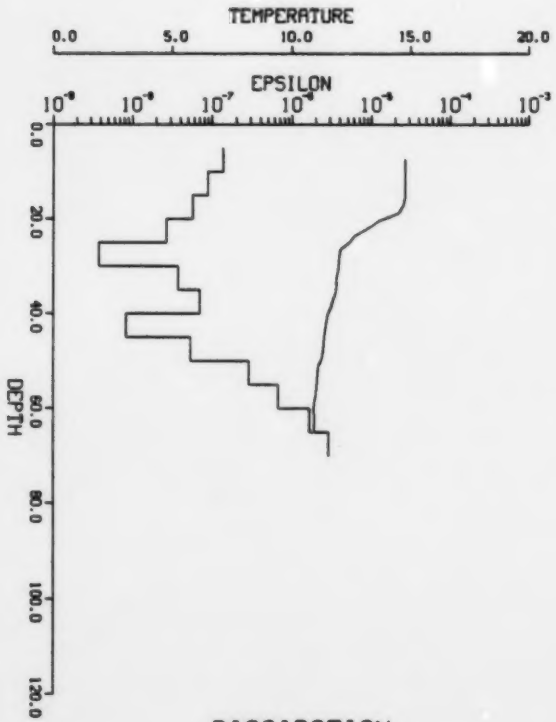

COX NUMBER B




88036 - 217 CHI-THETA

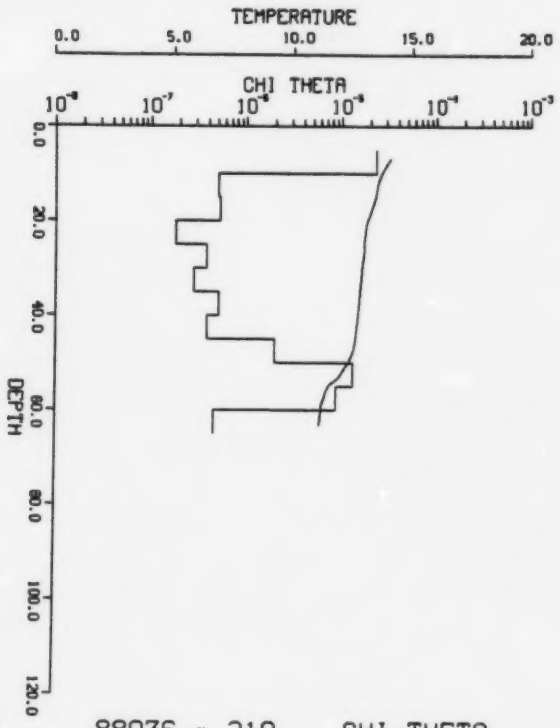



VERT DIFFUSIVITY

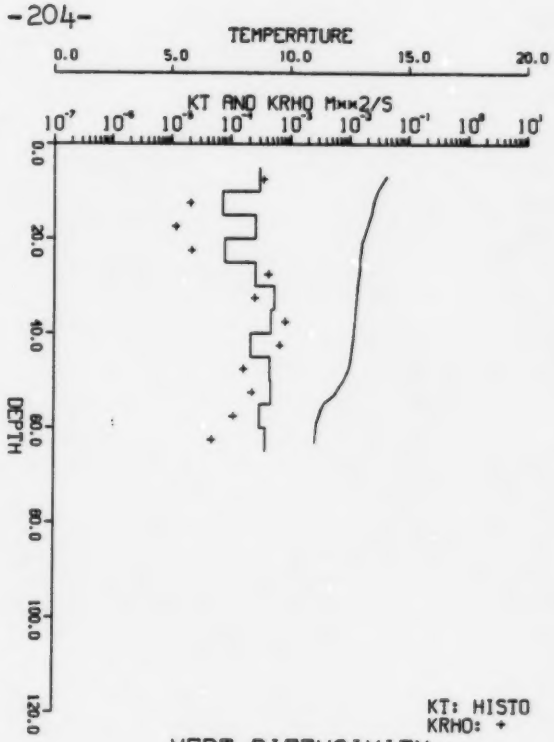



DISSIPATION

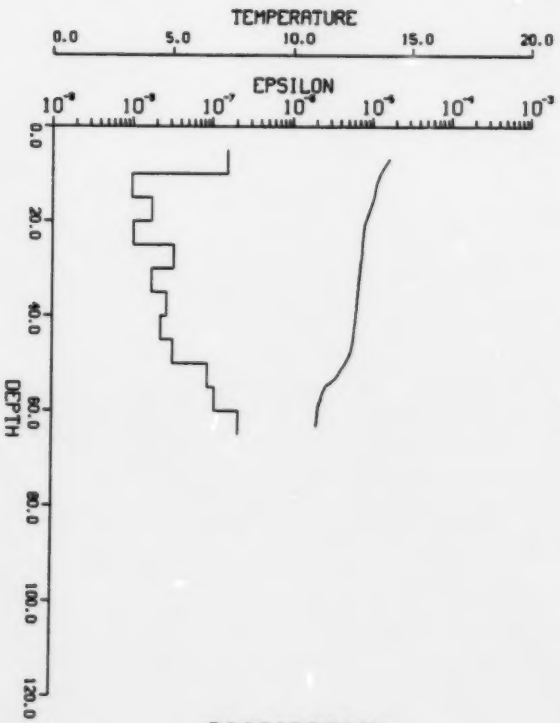
COX NUMBER C




88036 - 219 CHI-THETA




VERT DIFFUSIVITY

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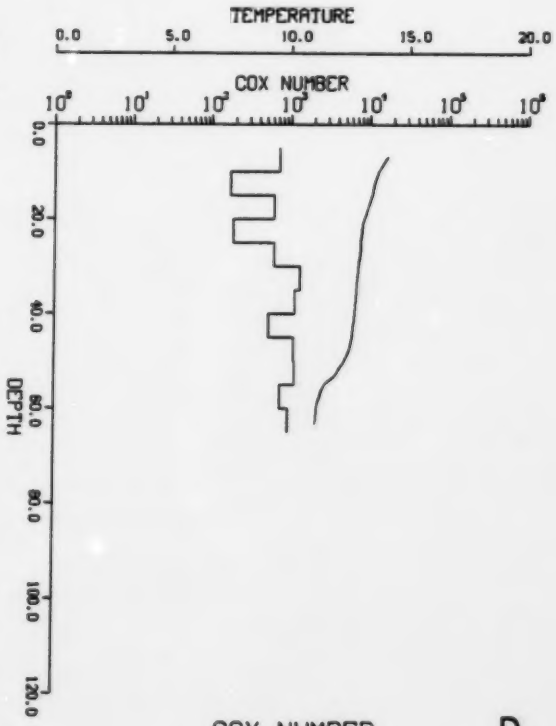
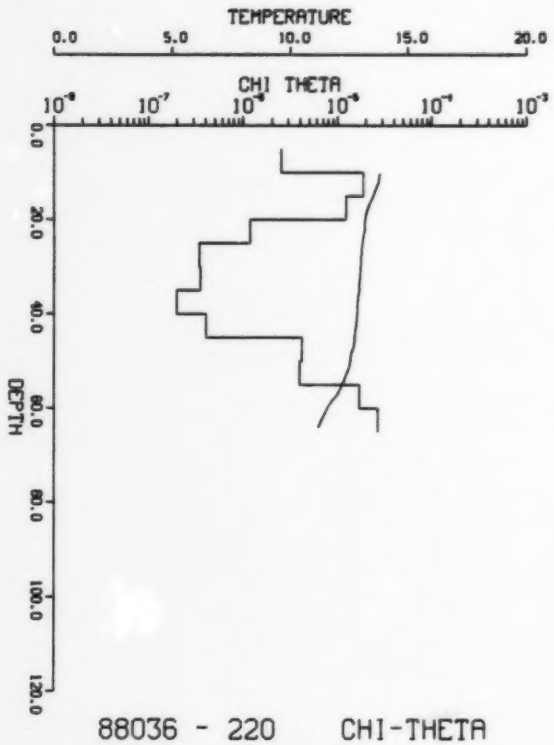
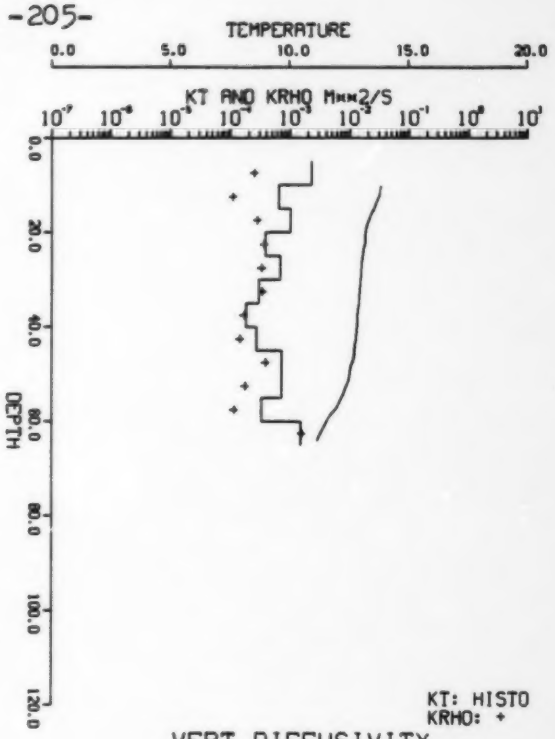



COX NUMBER

D




88036 - 220 CHI-THETA

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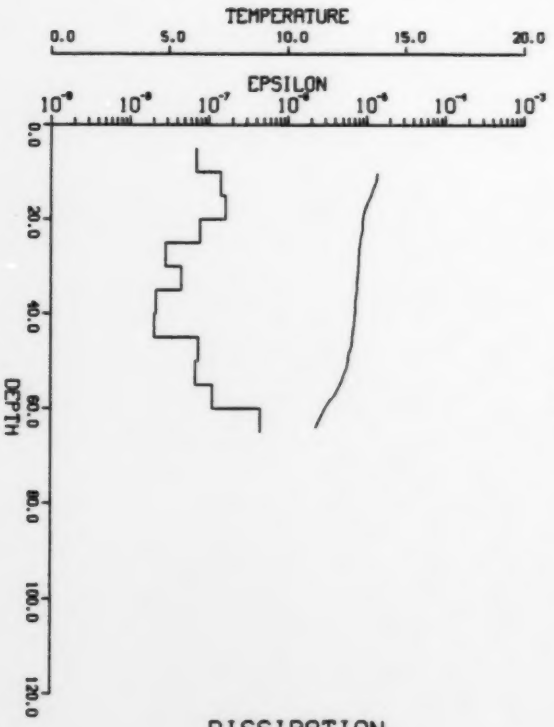


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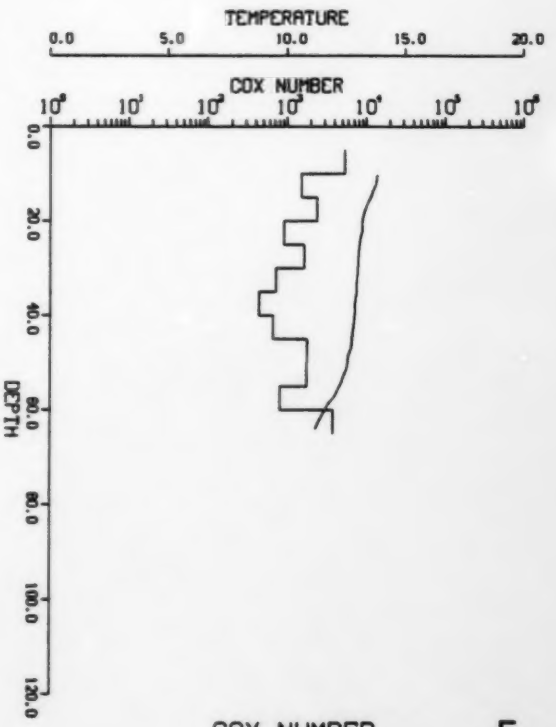
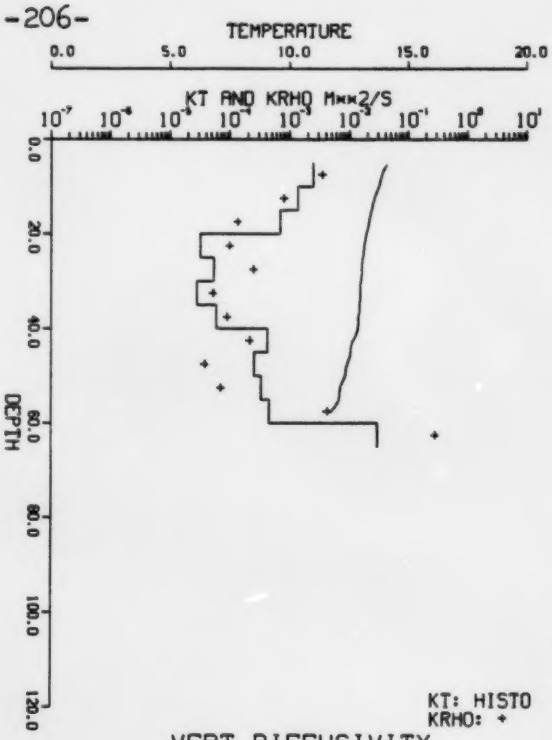
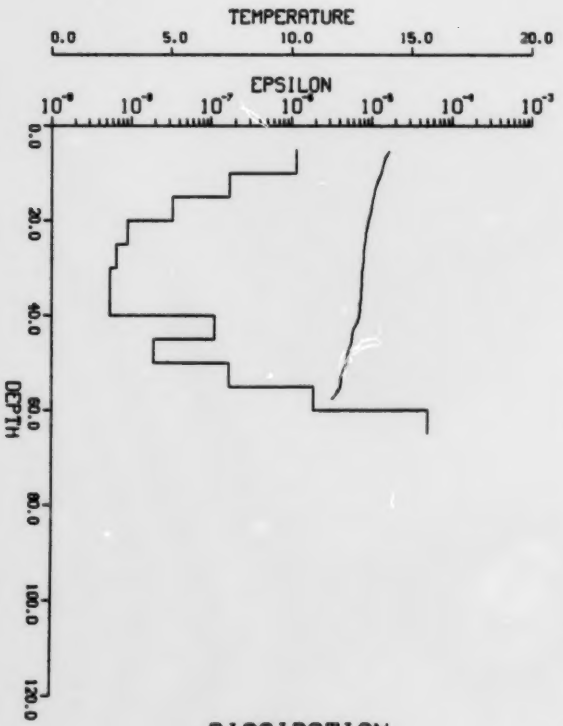



COX NUMBER E

88036 - 221 CHI-THETA



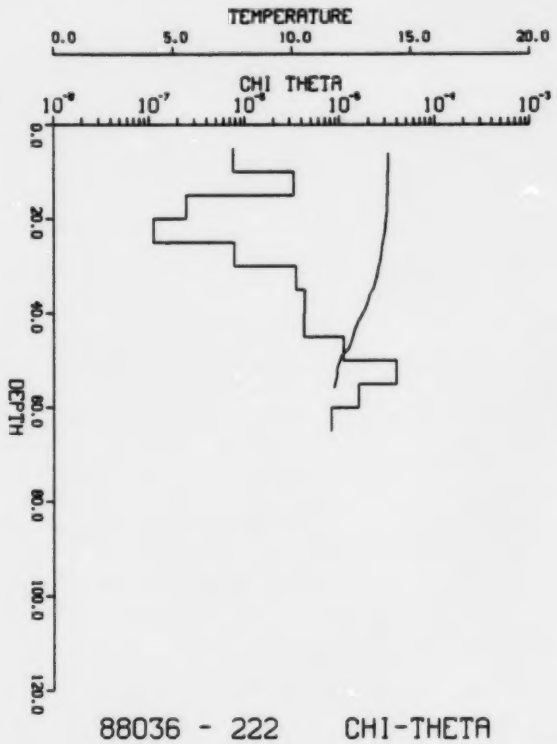

VERT DIFFUSIVITY



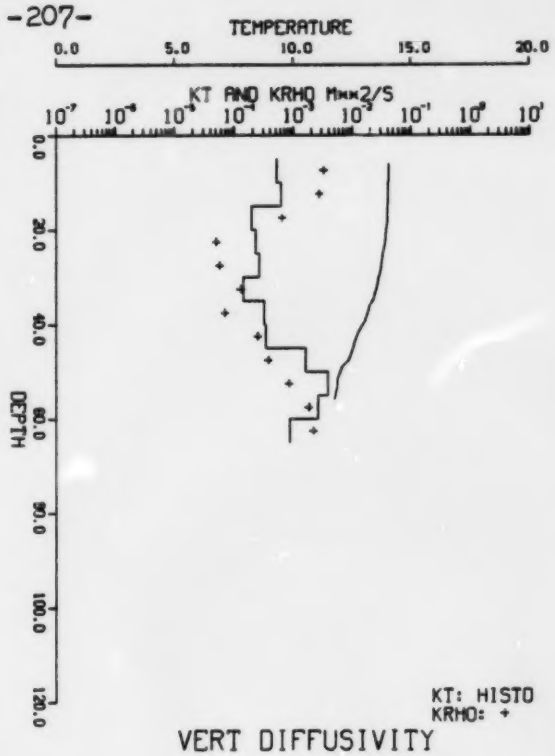

DISSIPATION

COX NUMBER

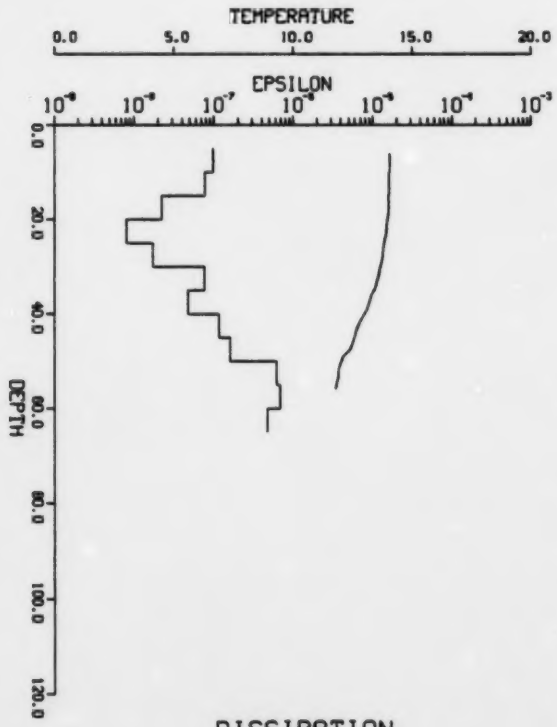
F




88036 - 222 CHI-THETA




VERT DIFFUSIVITY

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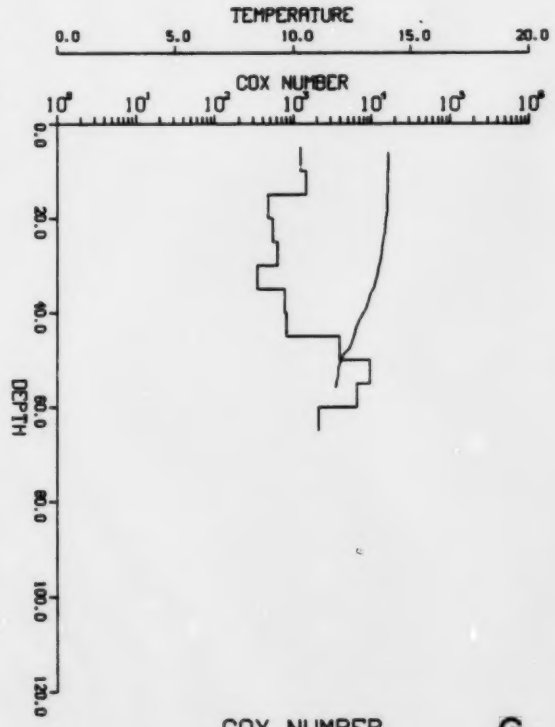
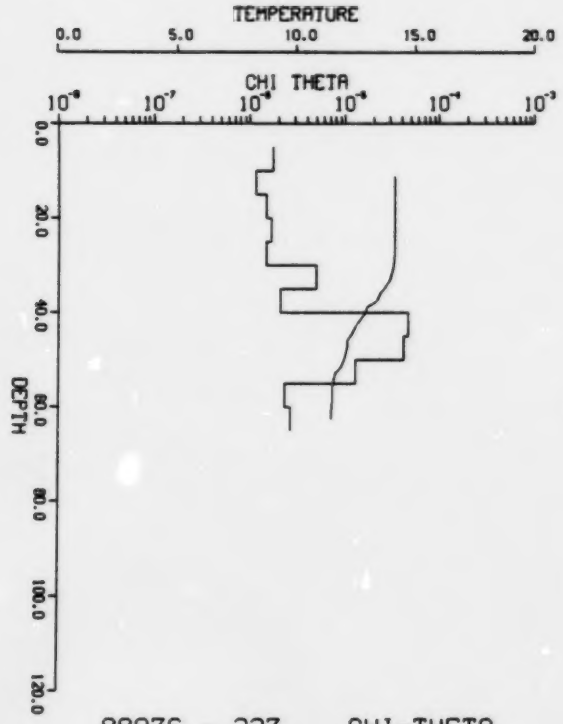
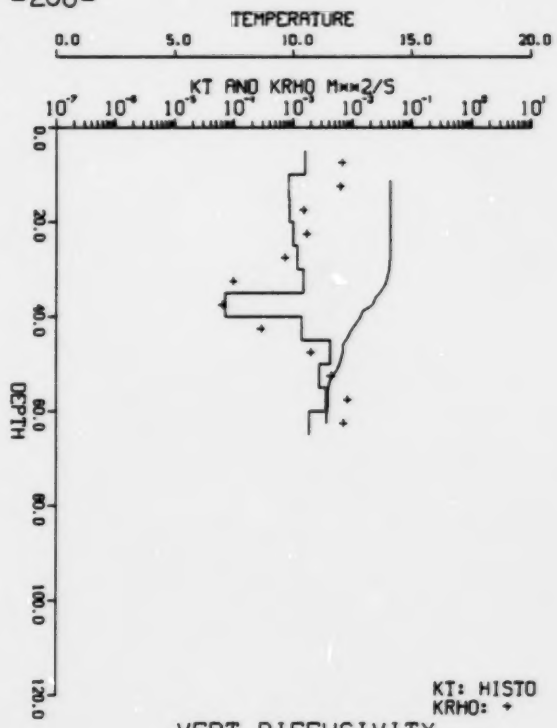



COX NUMBER

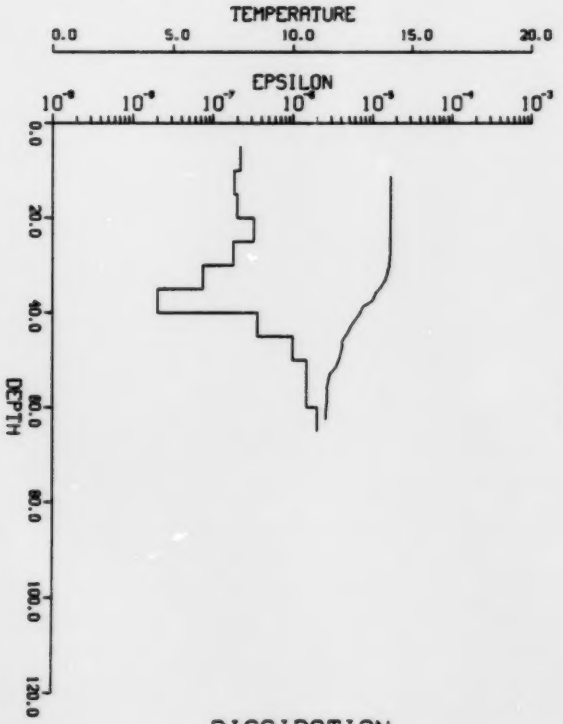
G



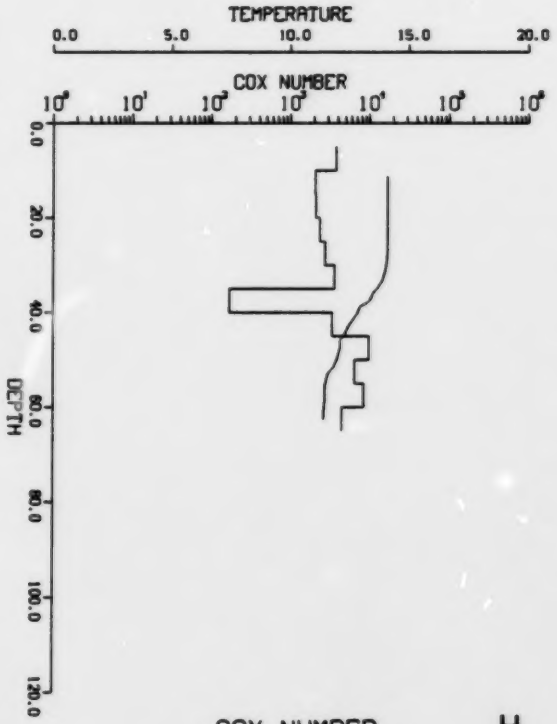

88036 - 223 CHI-THETA




VERT DIFFUSIVITY




DISSIPATION




COX NUMBER H

# SITE 4A36

41°53.29N, 66°46.36W

TABLE 13: COMBINED CURRENT AND DISSIPATION

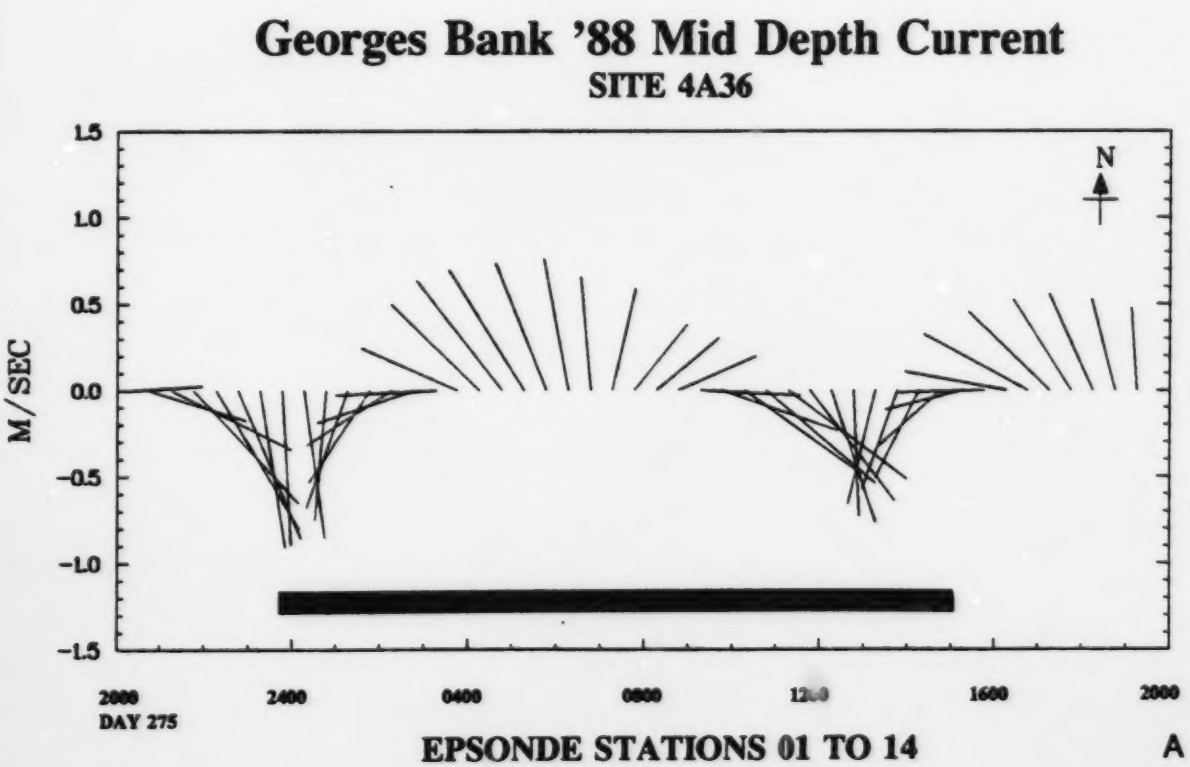
| Station | TimeEPS | Depth | Drops | Current | IntEPS | ErrEPS |
|---|---|---|---|---|---|---|
| E201 | 275.9979 | 60.15 | 8 | 0.930 | 0.4171 | 0.1129 |
| E202 | 276.0510 | 59.95 | 8 | 0.713 | 0.1243 | 0.0241 |
| E203 | 276.1358 | 60.20 | 4 | 0.597 | 0.0325 | 0.0062 |
| E204 | 276.1708 | 60.50 | 4 | 0.642 | 0.0421 | 0.0107 |
| E205 | 276.2226 | 61.20 | 8 | 0.725 | 0.1409 | 0.0204 |
| E206 | 276.2719 | 61.70 | 6 | 0.677 | 0.0603 | 0.0163 |
| E207 | 276.3217 | 61.70 | 8 | 0.547 | 0.0591 | 0.0125 |
| E208 | 276.3844 | 60.60 | 8 | 0.586 | 0.0286 | 0.0058 |
| E209 | 276.4233 | 59.85 | 8 | 0.705 | 0.0843 | 0.0247 |
| E210 | 276.4646 | 60.05 | 8 | 0.817 | 0.1883 | 0.0423 |
| E211 | 276.5295 | 59.85 | 5 | 0.743 | 0.1527 | 0.0340 |
| E212 | 276.5740 | 59.95 | 8 | 0.623 | 0.0768 | 0.0162 |
| E214 | 276.6191 | 57.75 | 7 | 0.505 | 0.0433 | 0.0094 |

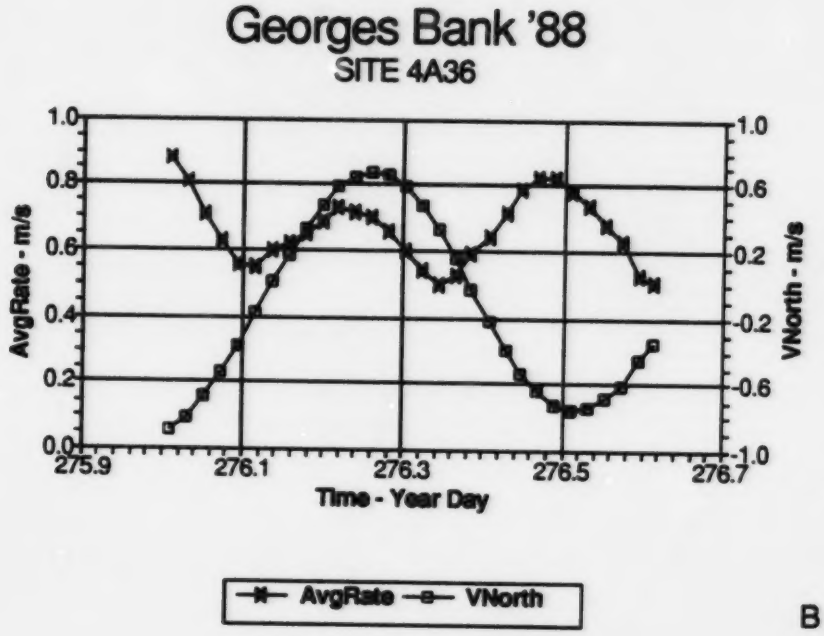
FIGURE 28:

A. Current vector plot for the RCM at 34m depth at site 4 overlapping the EPSONDE anchor station 4A during cruise 88036 (4A36). This anchor station includes EPSONDE stations 201 to 214.

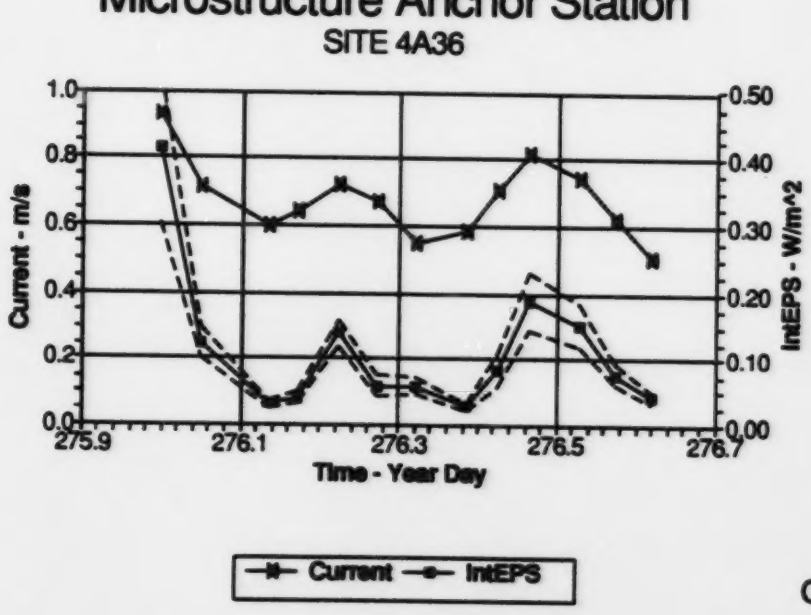
B. The magnitude and the northward component of the vertically averaged composite RCM and Ametek DCP current at half hourly intervals for site 4 coincident with EPSONDE anchor station 4A36.

C. The magnitude of the vertically averaged composite current interpolated to the mean EPSONDE station time and the integrated dissipation, IntEPS, for each EPSONDE station during anchor station 4A36. Error limits are indicated for IntEPS.




Georges Bank '88
SITE 4A36
AvgRate - m/s
VNorth - m/s
Time - Year Day
AvgRate
VNorth

B

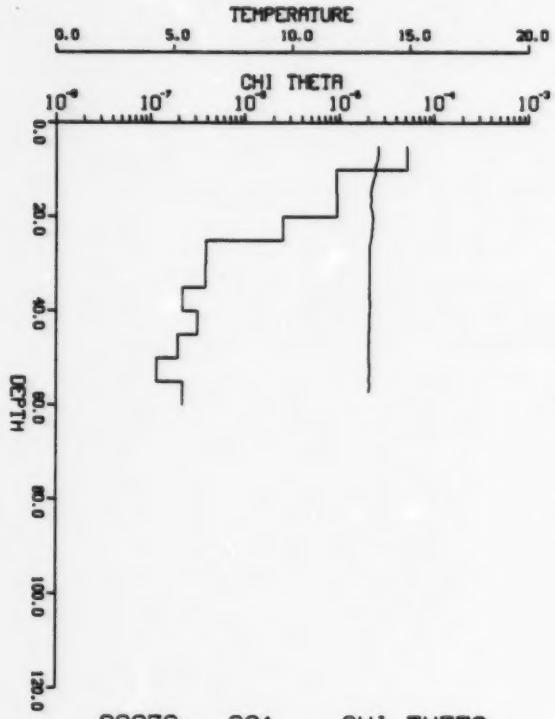

Microstructure Anchor Station
SITE 4A36
Current - m/s
IntEPS - W/m^2
Time - Year Day
Current
IntEPS

C

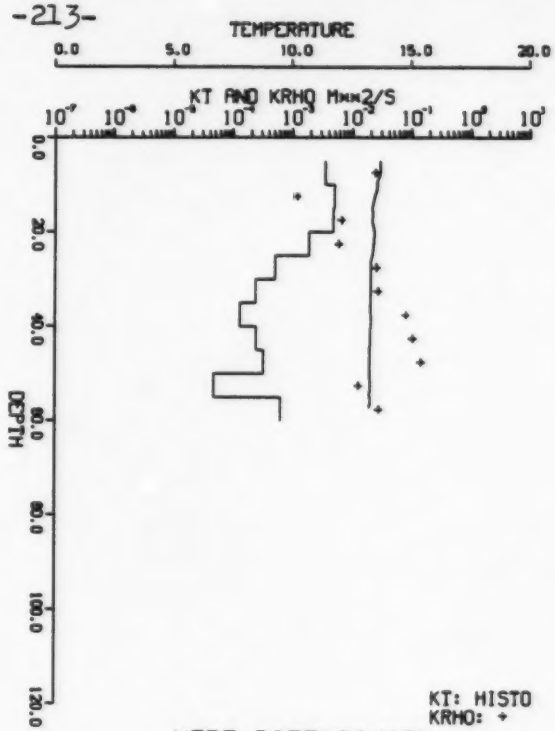
FIGURE 29: Profiles of microstructure quantities for stations 201 to 214 for anchor station 4A36.
- Each page contains a profile of a microstructure quantity averaged over 5 m vertical bins overlaid on a profile of temperature.
- The upper left panel is Chi-Theta, the dissipation of temperature variance.
- The upper right panel contains profiles of vertical diffusivity KT (for temperature) and KRHO for density.
- The lower left panel contains a profile of dissipation, EPSILON.
- The lower right panel shows the profile for Cox number.

The stations are shown in the following order:

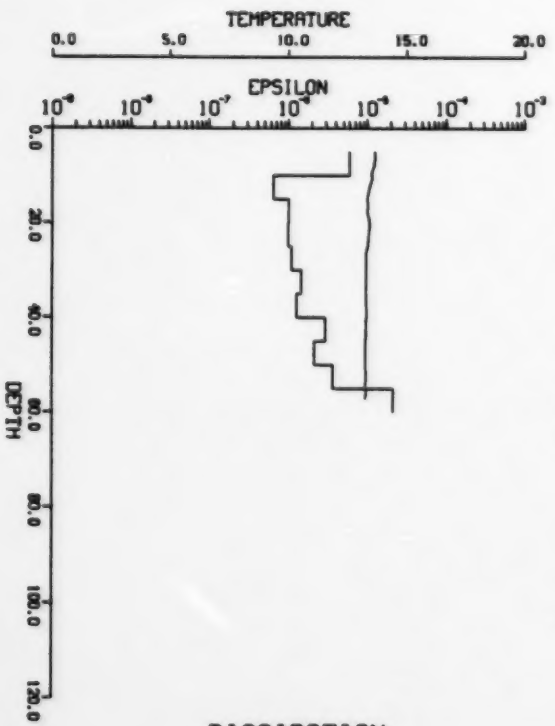
A. Station 201
B. Station 202
C. Station 203
D. Station 204
E. Station 205
F. Station 206
G. Station 207
H. Station 208
I. Station 209
J. Station 210
K. Station 211
L. Station 212
M. Station 214



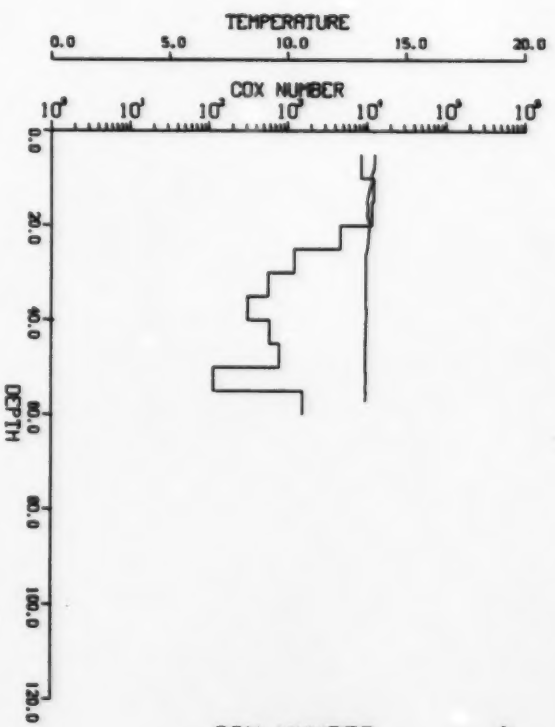

88036 - 201 CHI-THETA



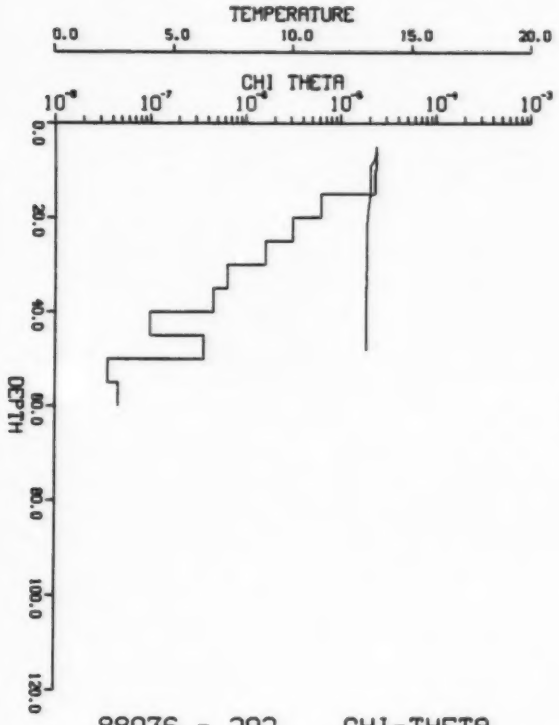

VERT DIFFUSIVITY



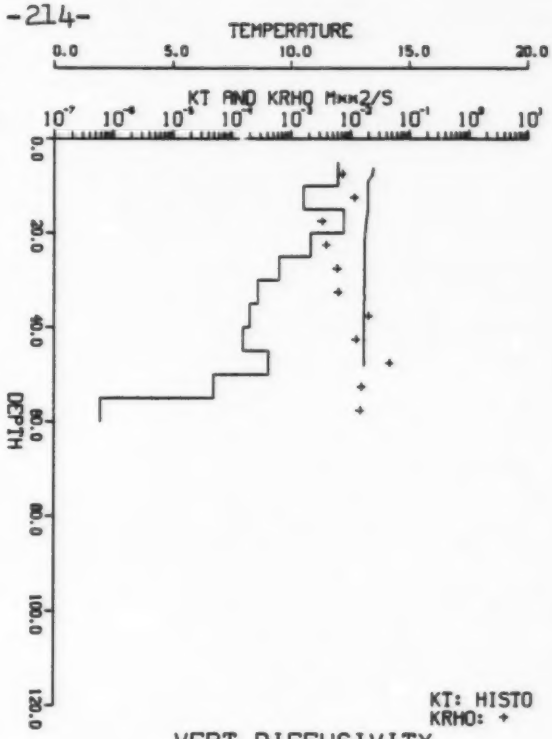

DISSIPATION




COX NUMBER A




88036 - 202 CHI-THETA

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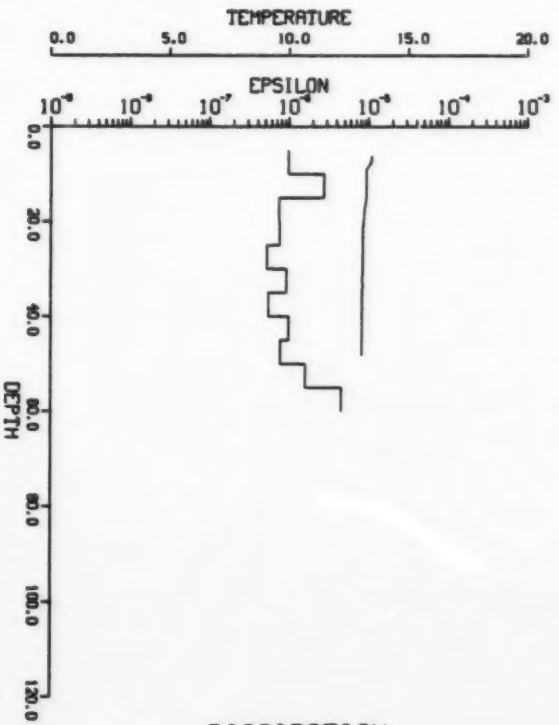


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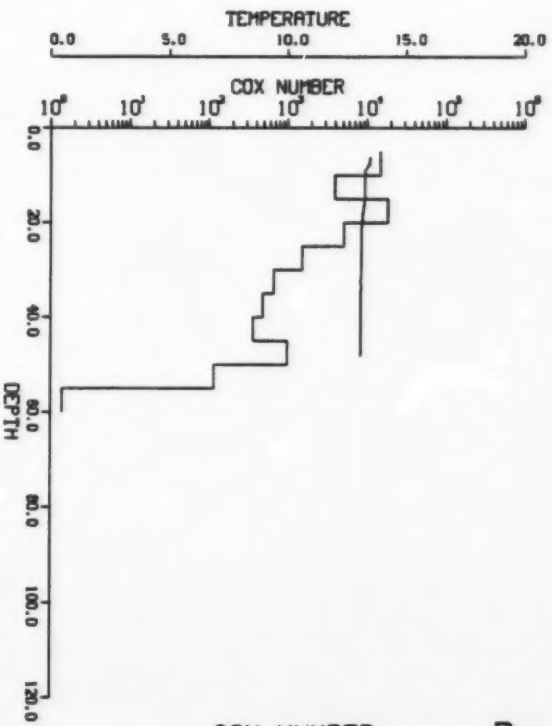


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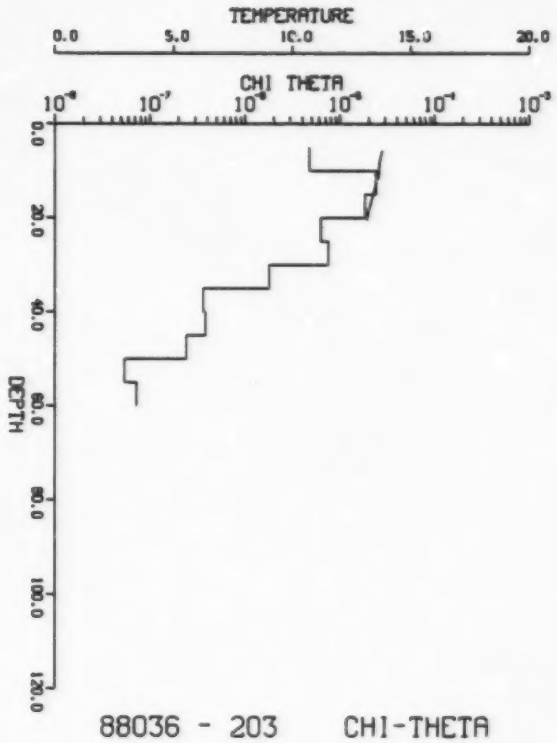
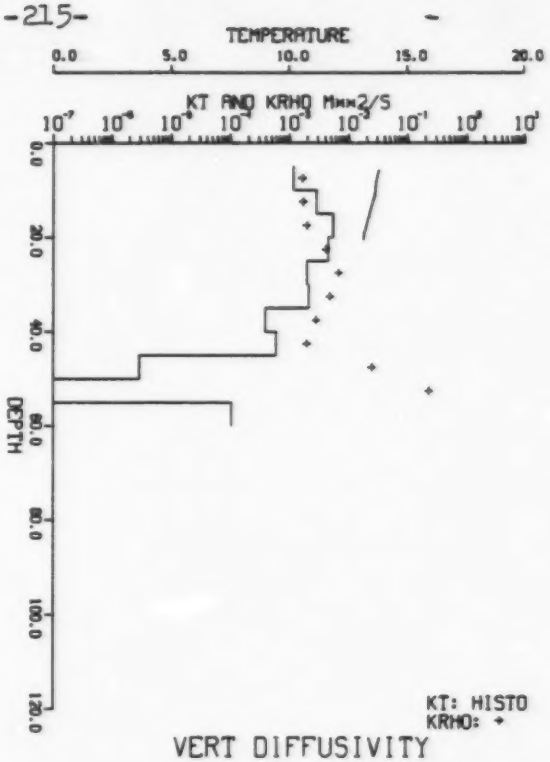
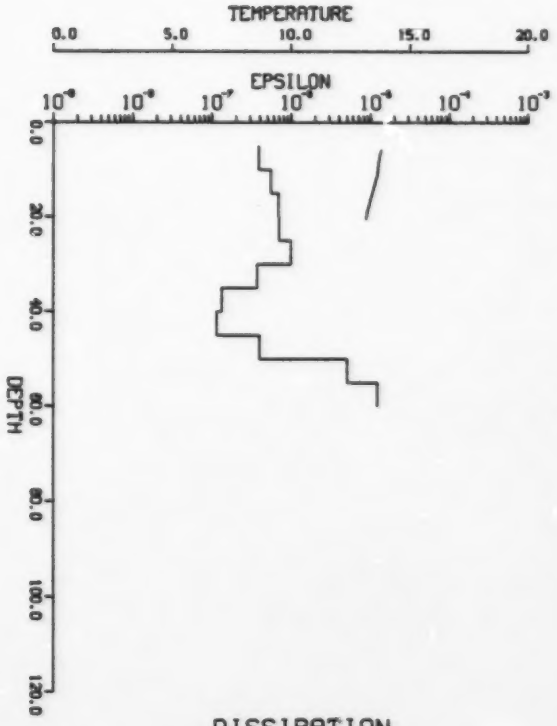



88036 - 203 CHI-THETA




VERT DIFFUSIVITY

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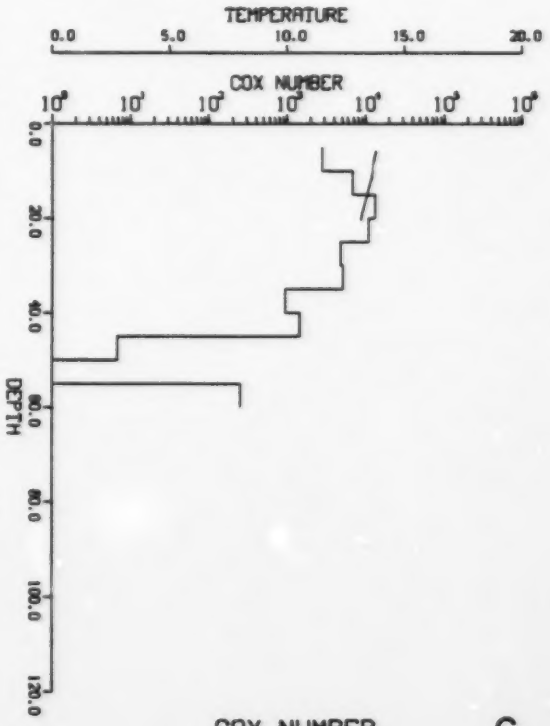


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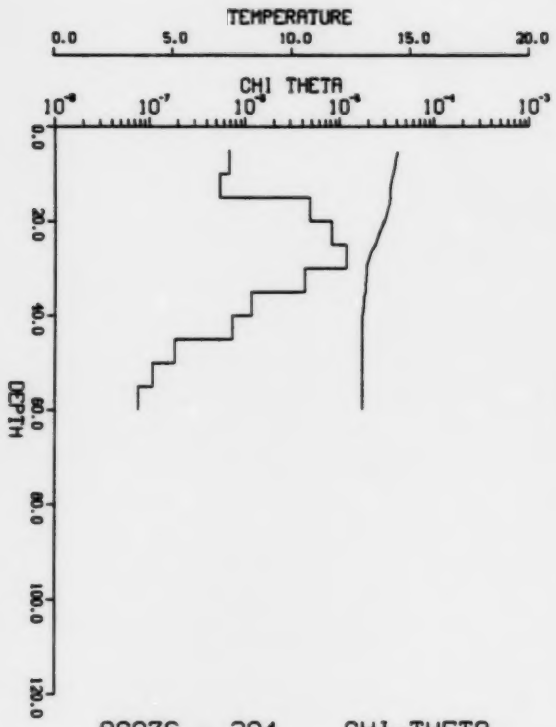
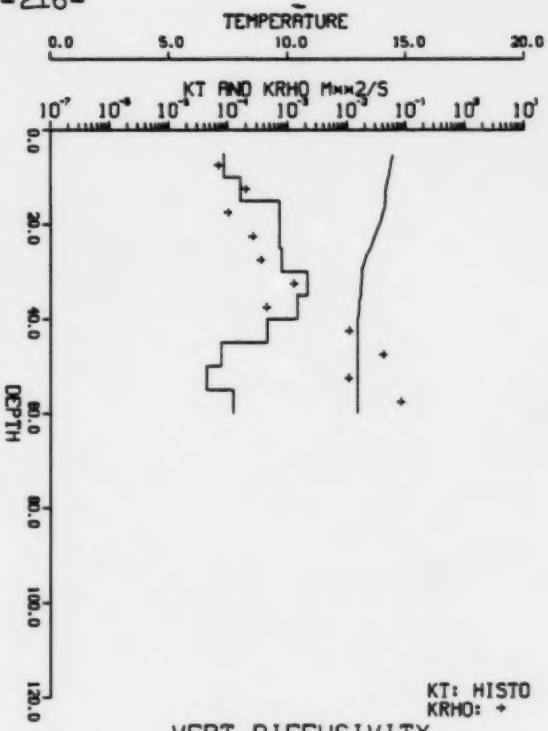



88036 - 204 CHI-THETA

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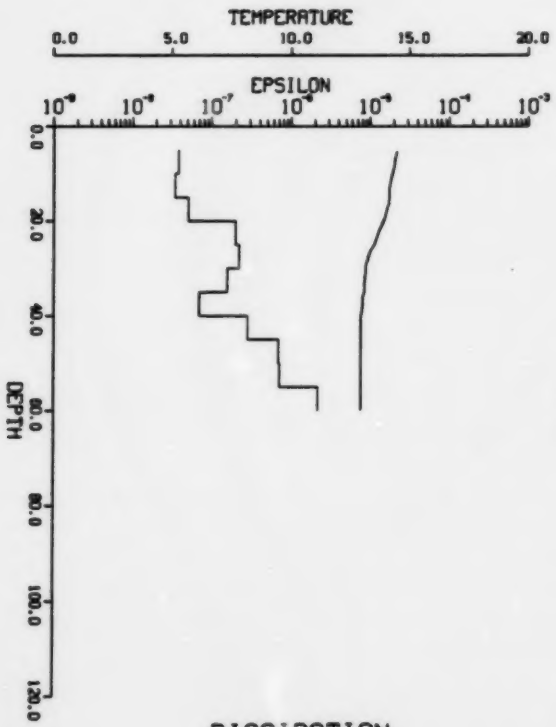


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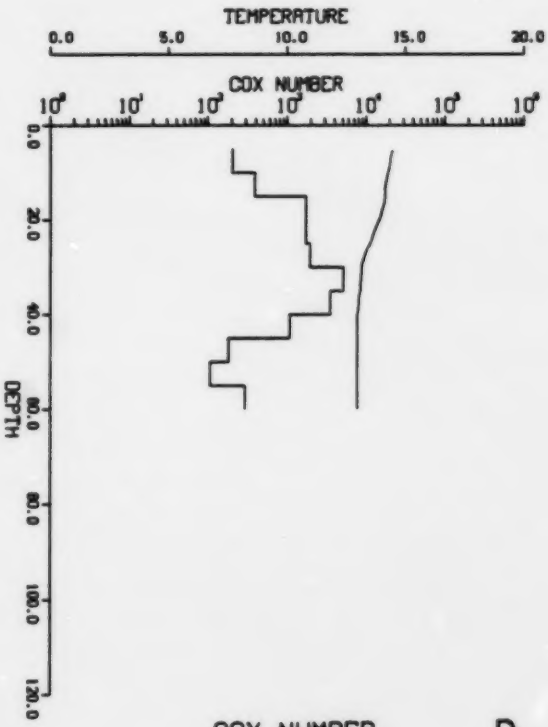


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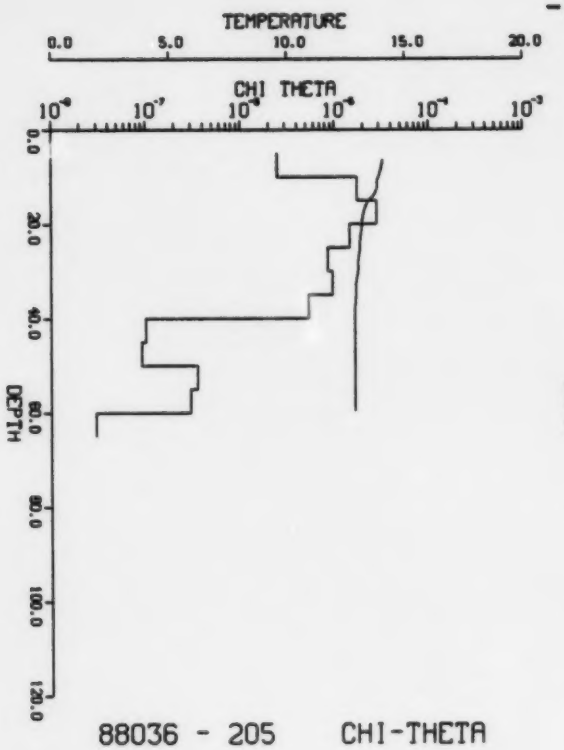
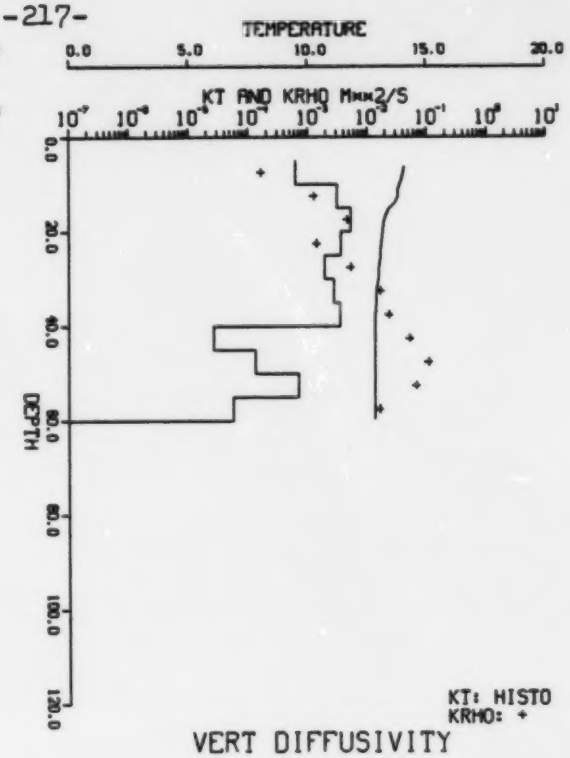



88036 - 205 CHI-THETA

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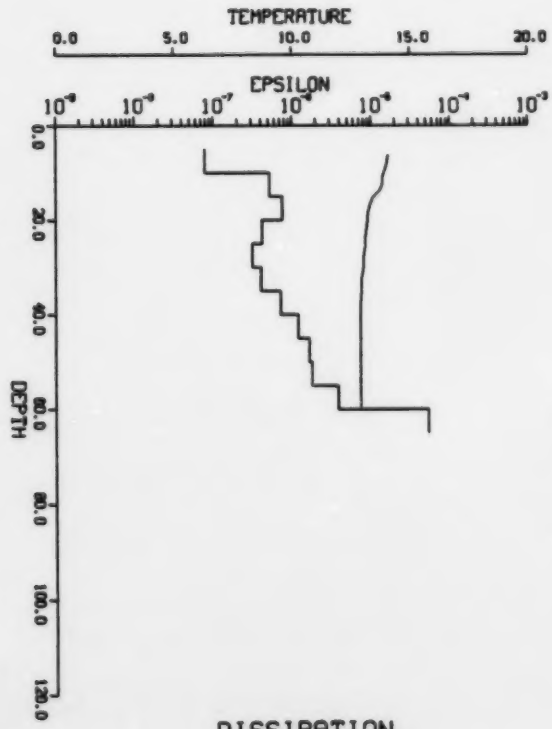


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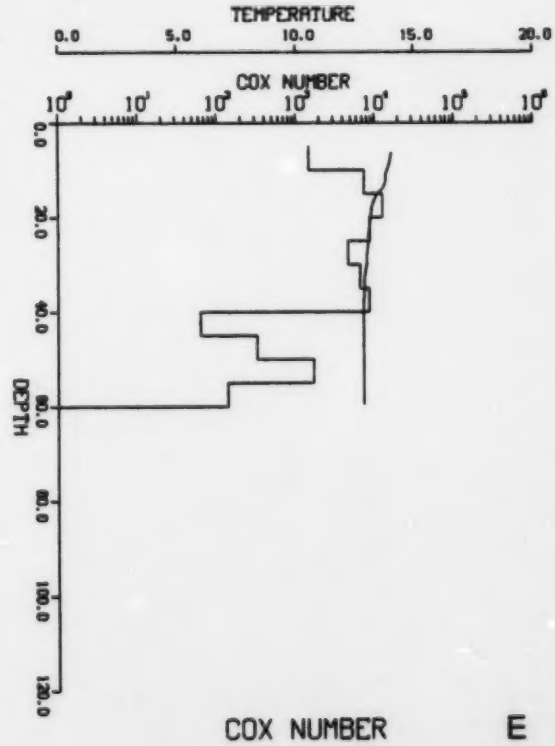


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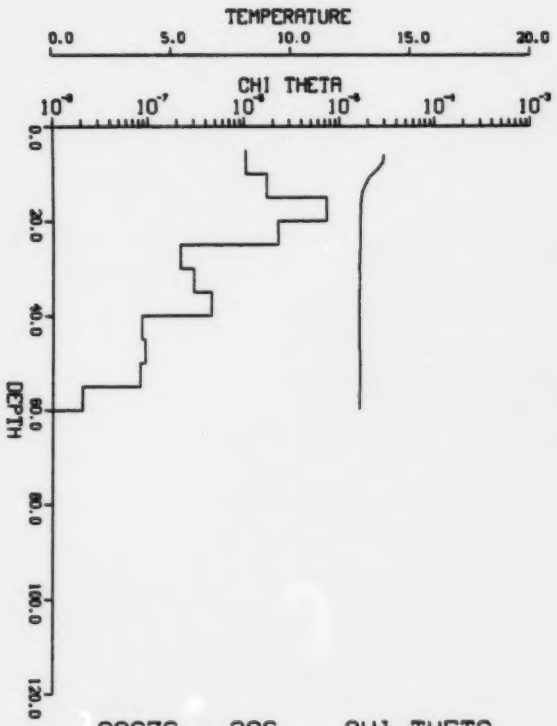
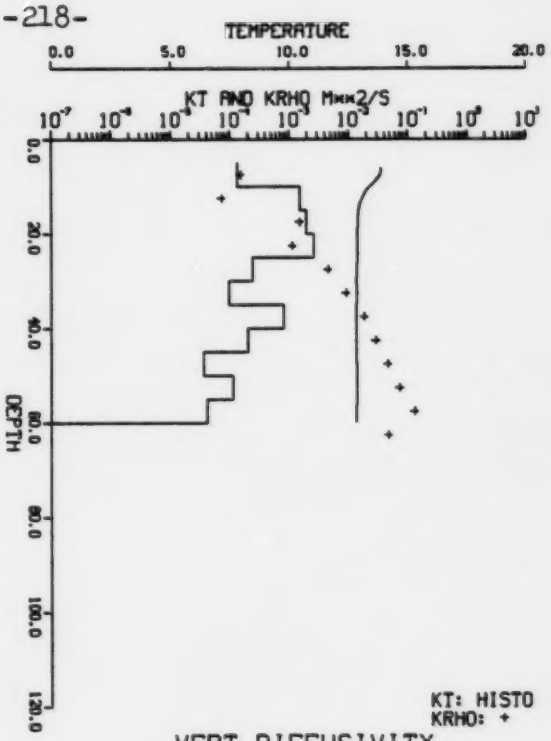



88036 - 206 CHI-THETA

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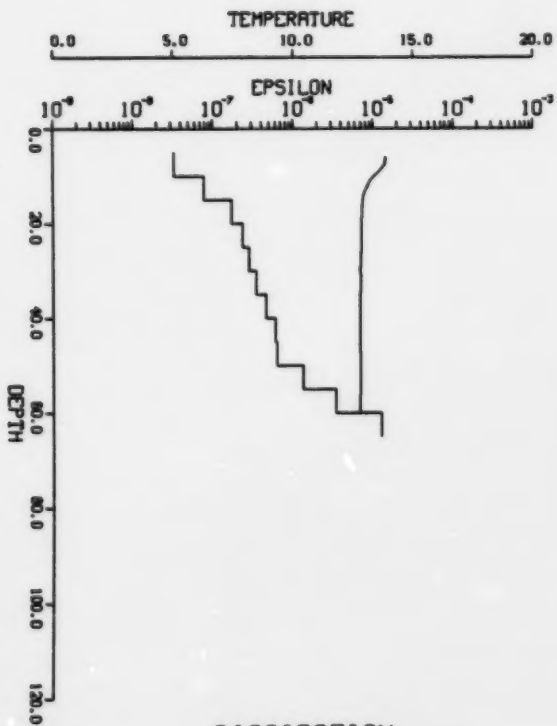


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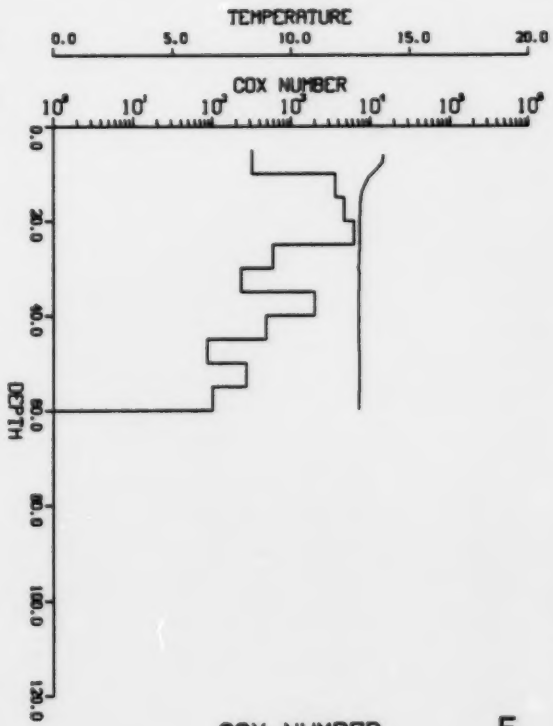


COX NUMBER

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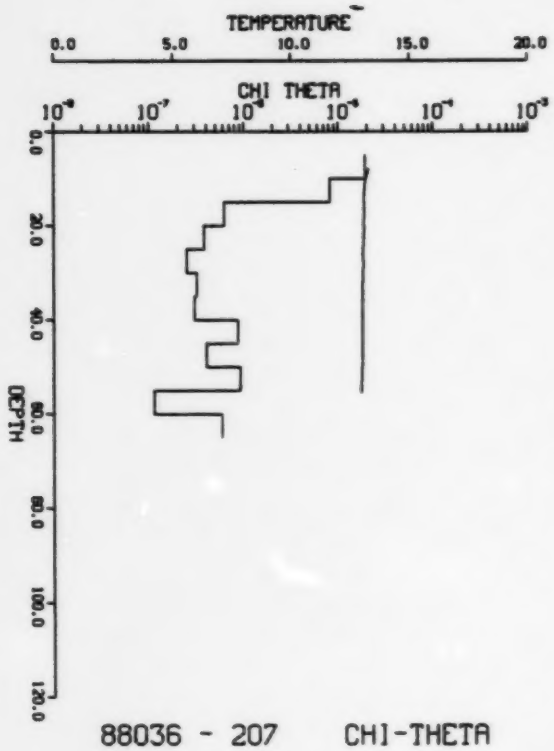
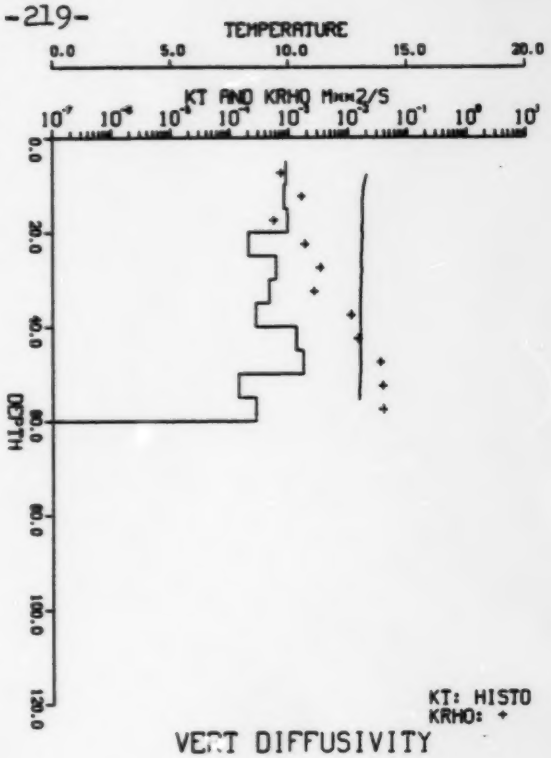



88036 - 207 CHI-THETA

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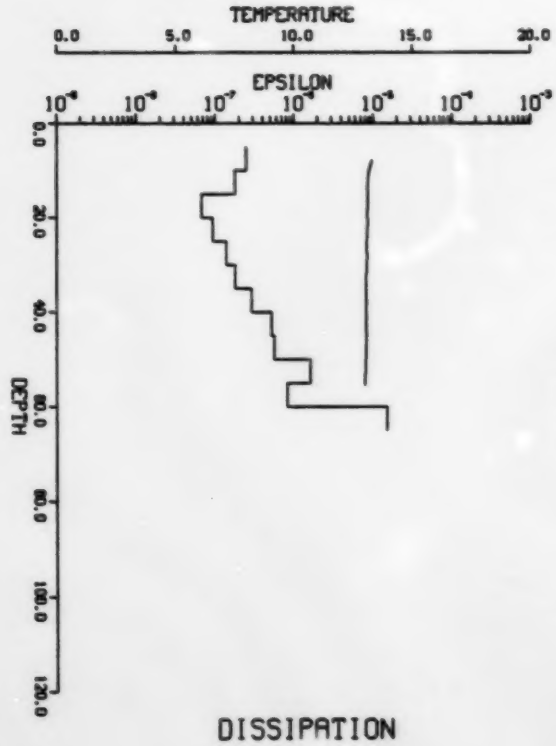


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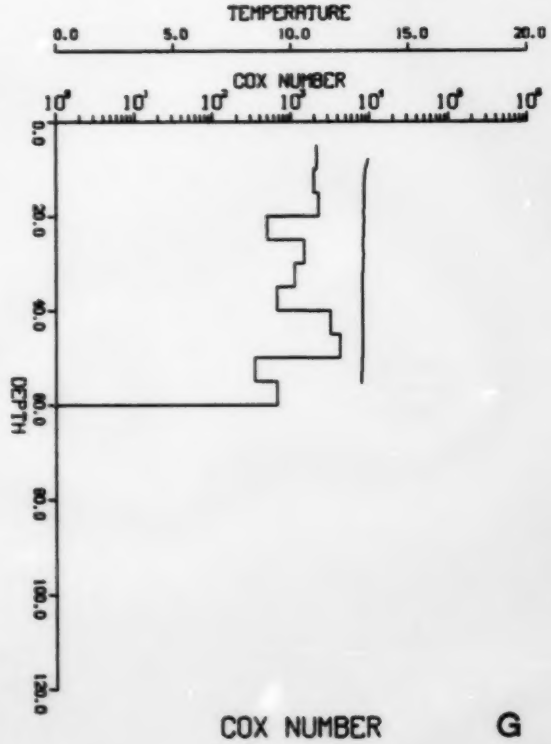


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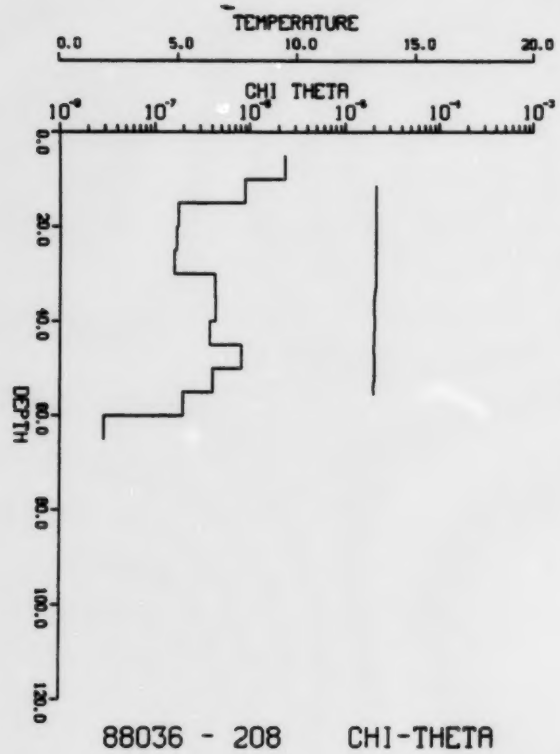
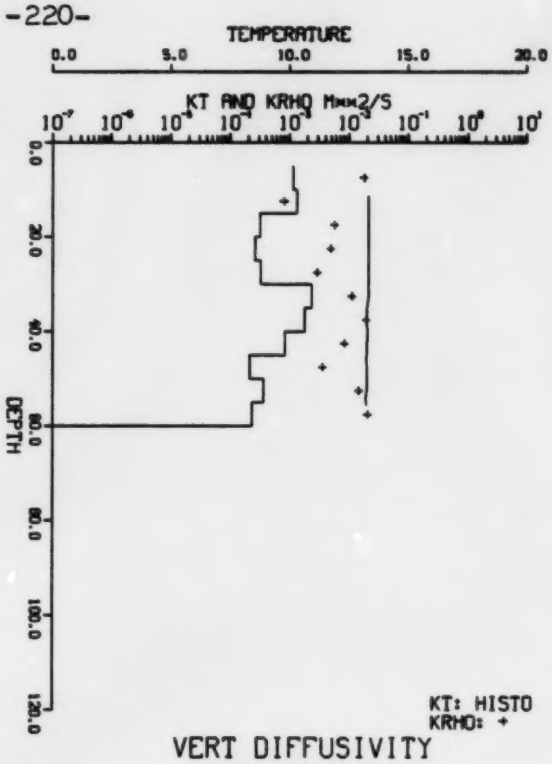



88036 - 208 CHI-THETA

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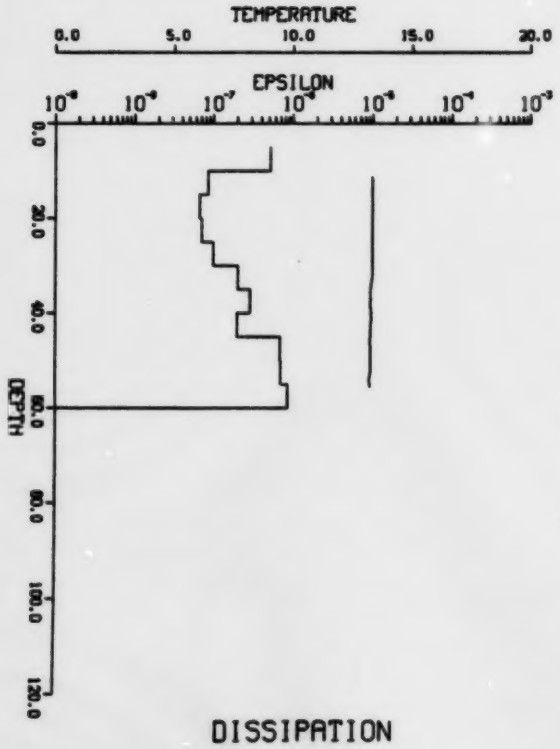


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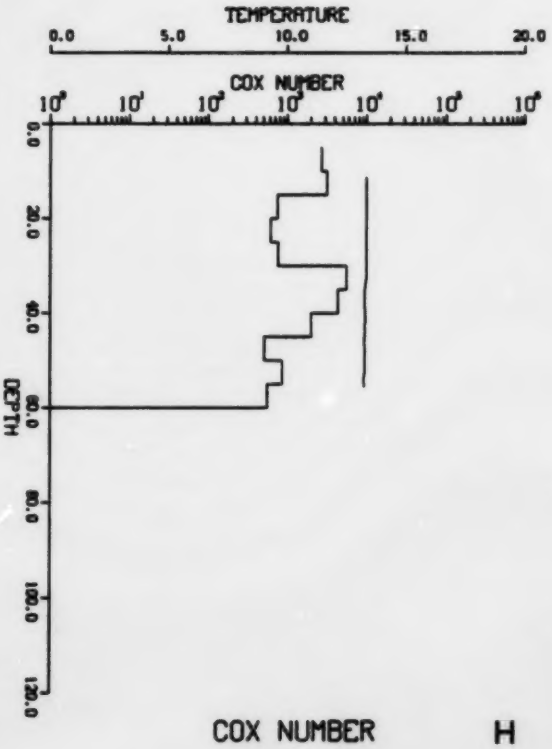
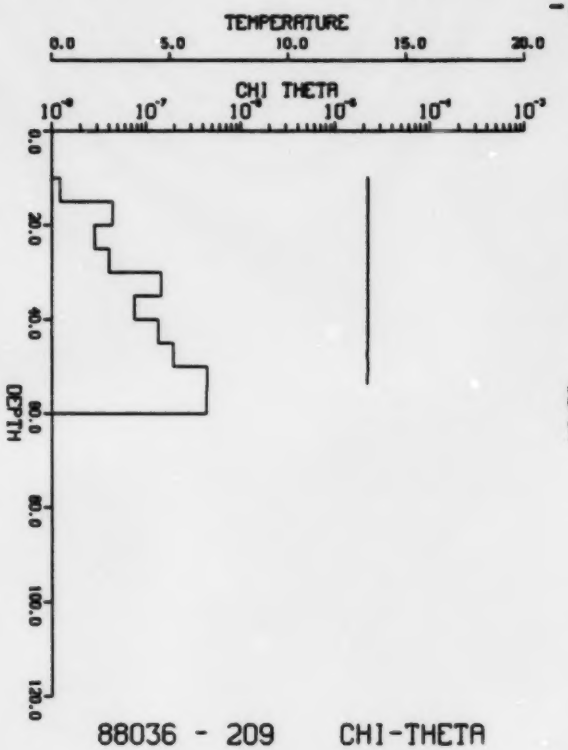
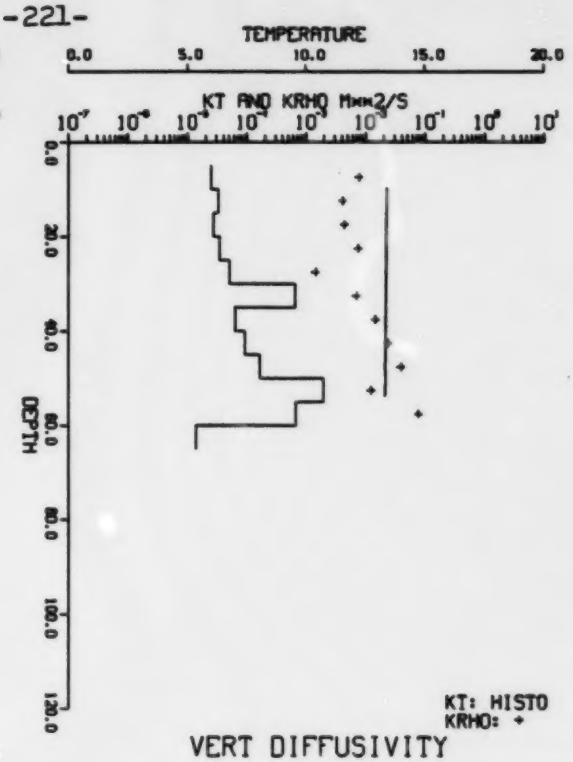



COX NUMBER H




88036 - 209 CHI-THETA

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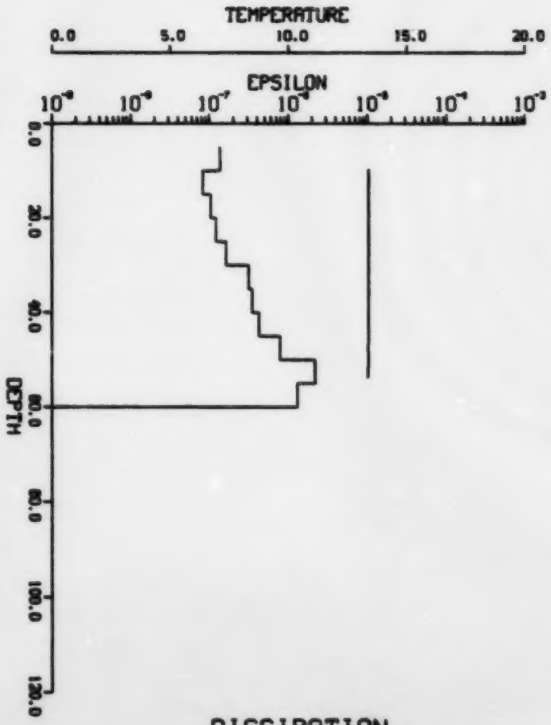


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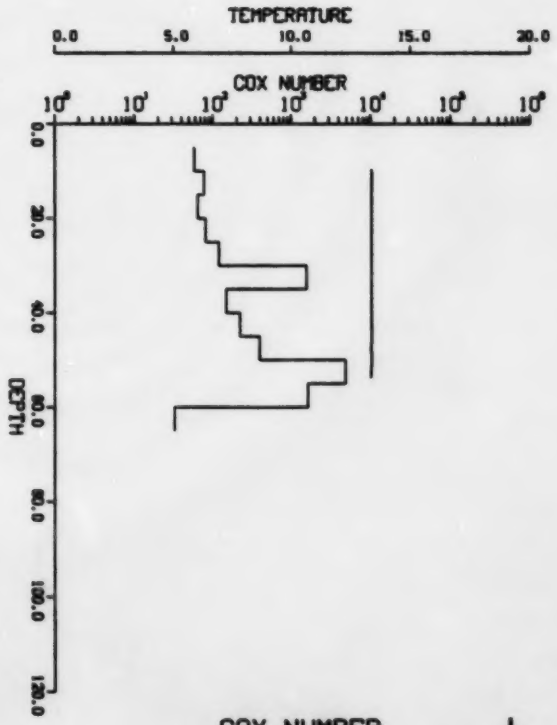


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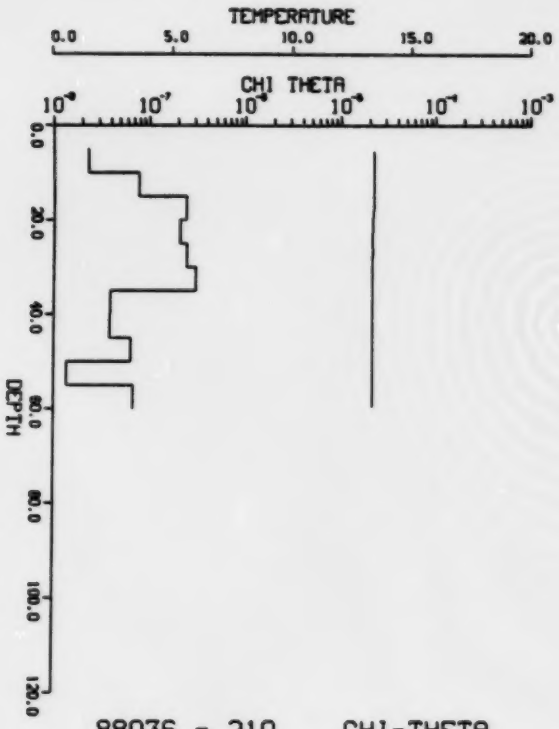
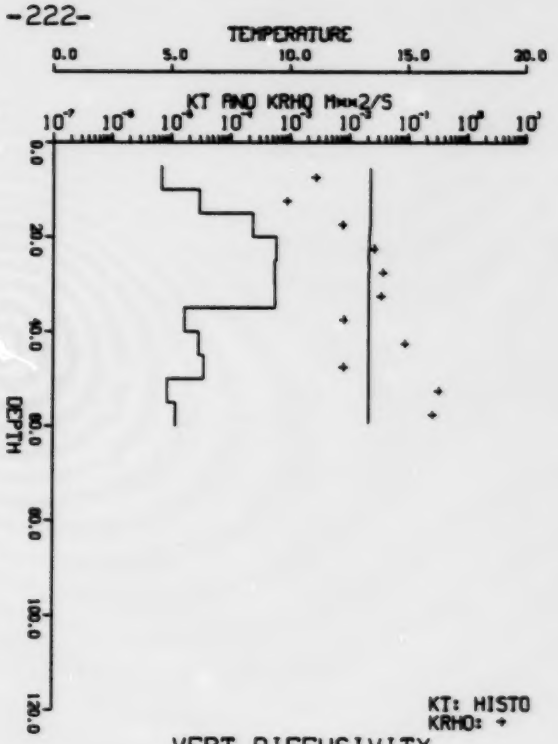



88036 - 210 CHI-THETA

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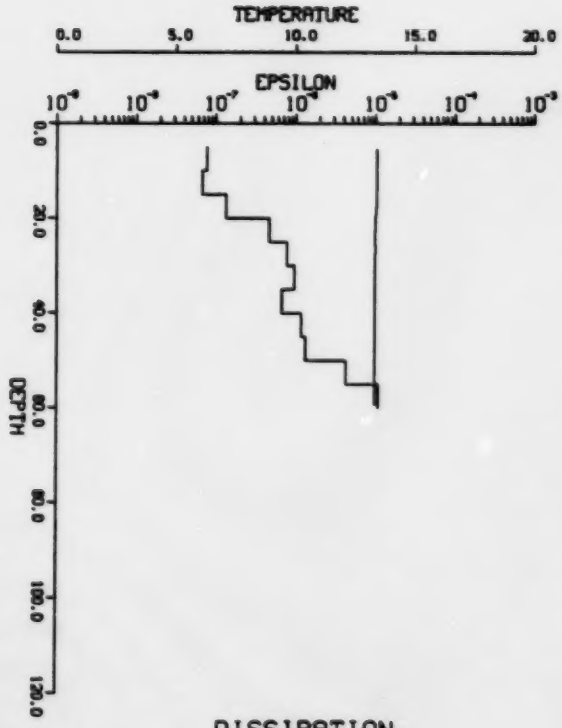


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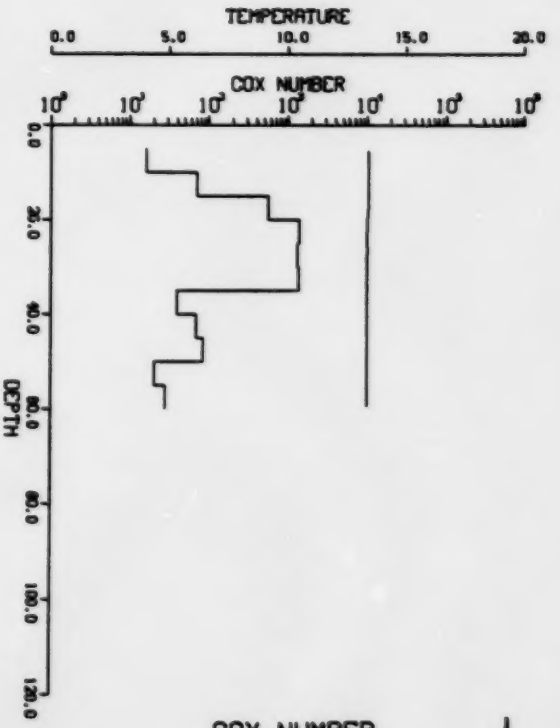


COX NUMBER

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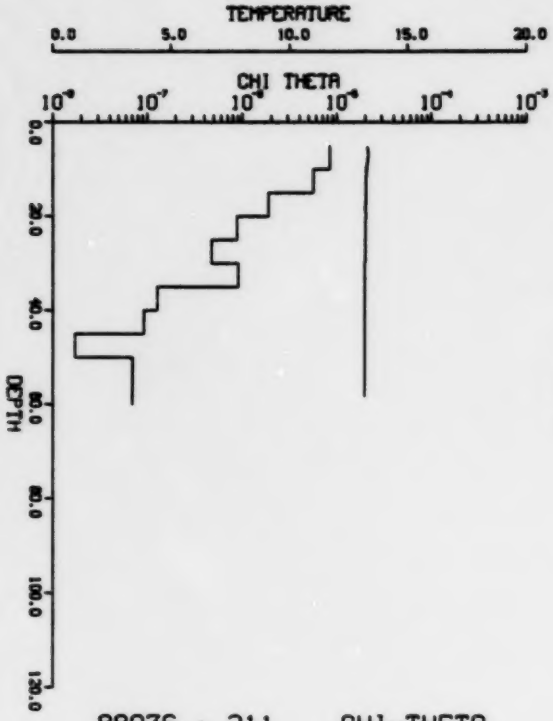
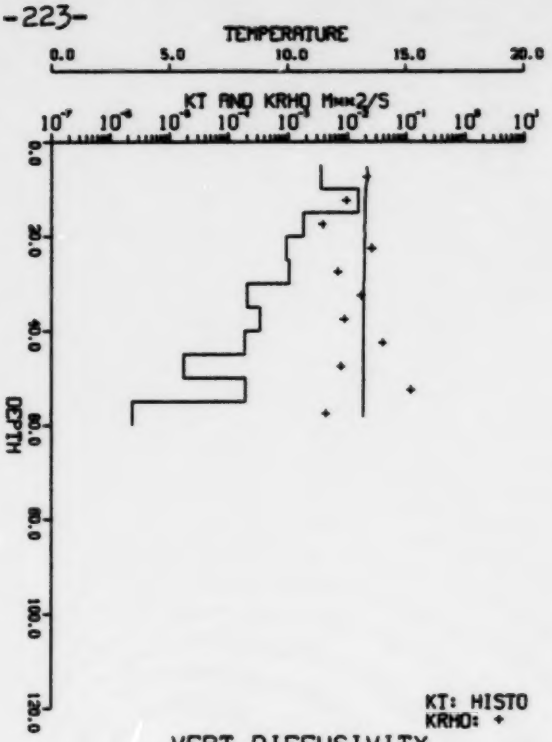
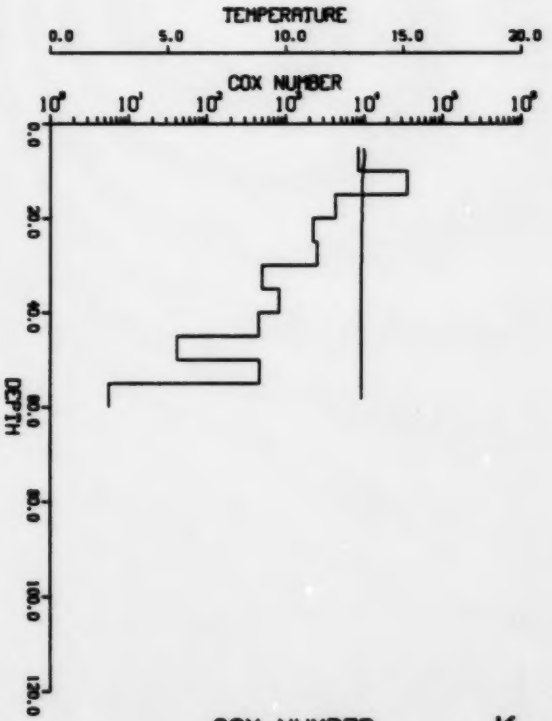



88036 - 211 CHI-THETA




VERT DIFFUSIVITY

DISSIPATION

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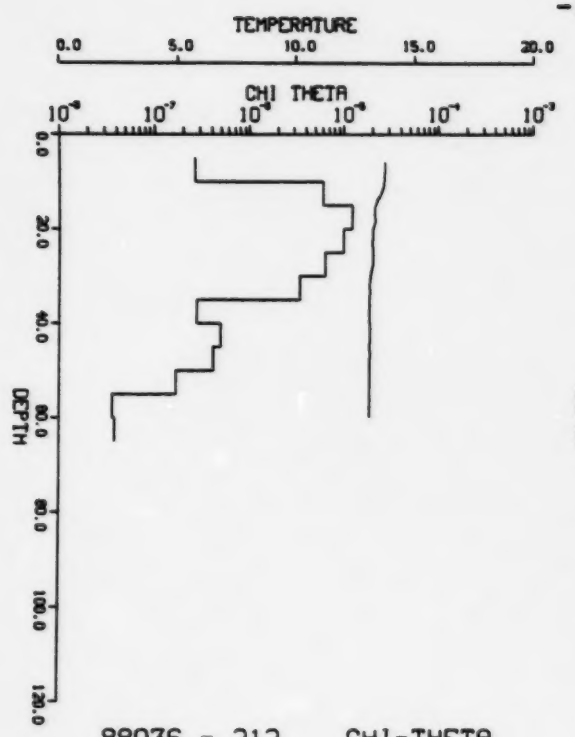
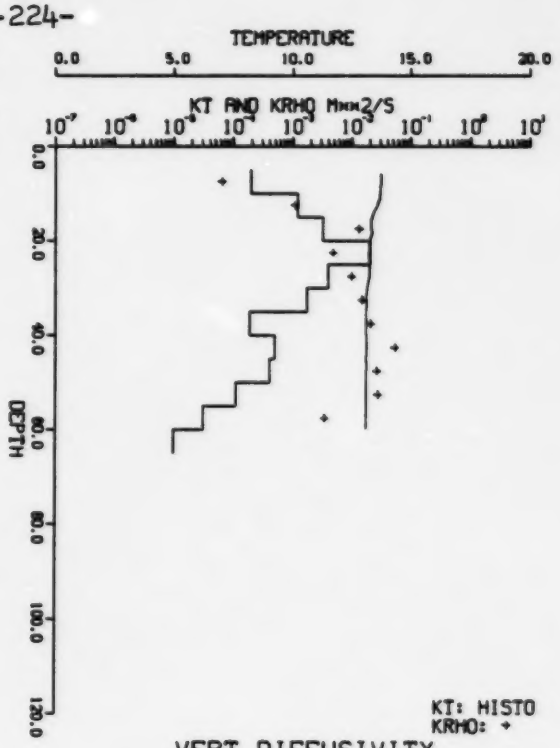
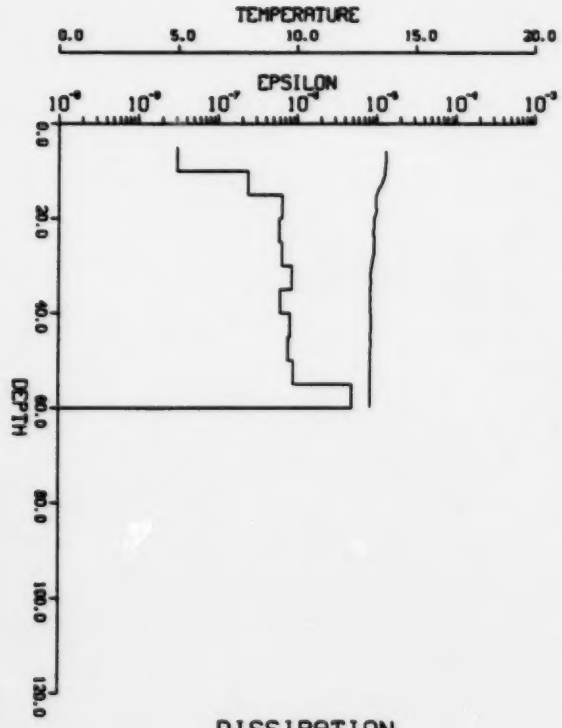



88036 - 212 CHI-THETA




VERT DIFFUSIVITY

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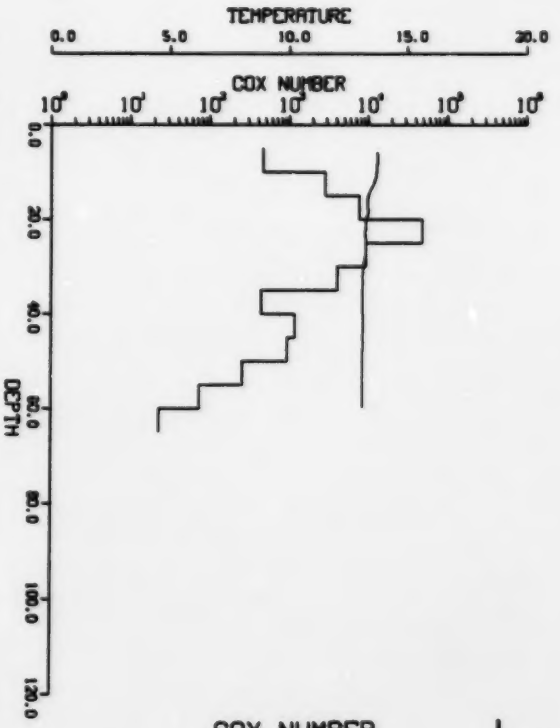
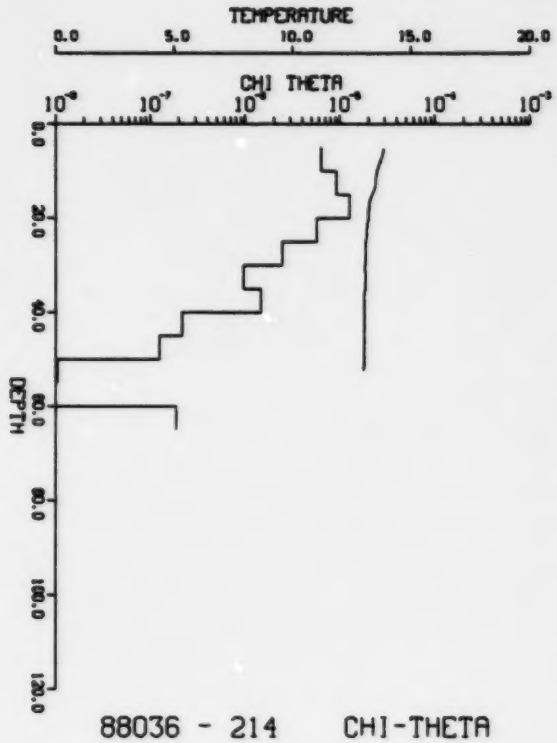
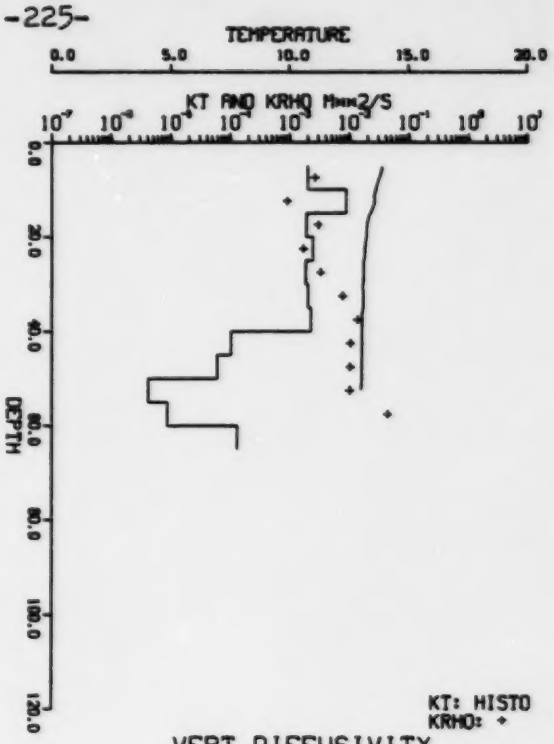



COX NUMBER L




88036 - 214 CHI-THETA

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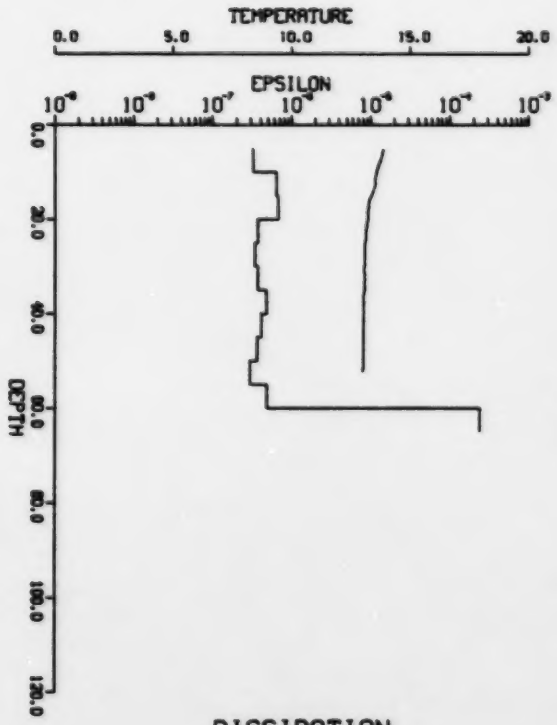


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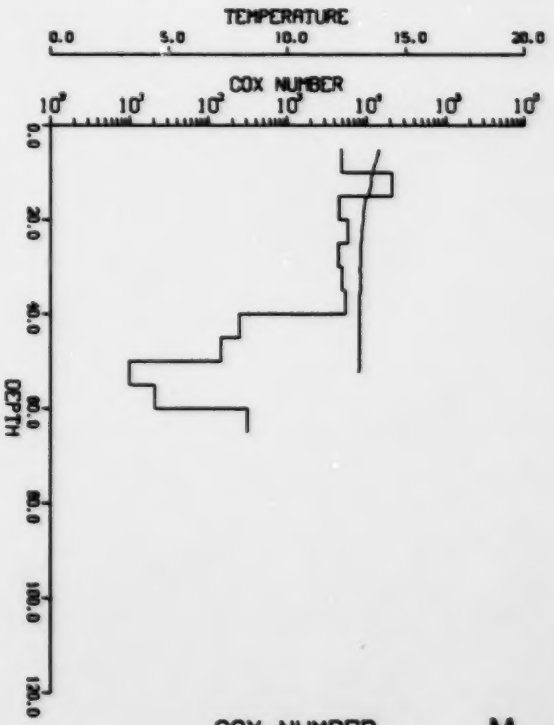


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